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WANTED: February, April, and June 1949 Numbers

The Association will pay 60¢ each cash or in a credit for any of the above issues. June numbers needed especially as an entire sack of mail destined for Oregon and Pennsylvania was lost and the Association desires to supply the missing numbers to libraries and individuals who did not get their Journals. Forward to Ernest N. Cory, College Park, Maryland.

JOURNAL OF ECONOMIC ENTOMOLOGY
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Comparative Effectiveness of DDT, Methoxychlor, and Dichlorodiphenyl Dichloroethane Residues Against House Flies and *Aëdes* Floodwater Mosquitoes

A. R. Roth and Arthur W. Lindquist, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Many investigators have observed that house flies and mosquitoes knocked down by DDT and other chlorinated hydrocarbon insecticides do not recover. However, Lindquist *et al.* (1945) obtained some recovery of house flies after they had been knocked down by exposure to DDT at 65° F. and then held at 100° for several hours.

It has also been observed that methoxychlor has a more rapid knock-down action on house flies than DDT. Recently the writers noted that house flies recovered after being knocked down by short exposures to residues of methoxychlor. This effect was evaluated more closely in a series of tests made to compare the speed of knock-down and recovery of house flies, *Musca domestica* L., exposed to residues of DDT, methoxychlor, and dichlorodiphenyl dichloroethane for different periods of time. Tests were also made with females of *Aëdes* flood-water mosquitoes, approximately 90 per cent being *A. sticticus* Meig. and 10 per cent *A. vexans* (Meig.) The comparison of DDT and methoxychlor was continued with different dosages as well as different exposure times.

Materials and Methods.—One quart glass jars, together with their screen wire covers, were treated with acetone solutions of the technical insecticides at rates of either 1 or 20 mg. of toxicant per square foot.

Flies from 4 to 7 days old were introduced into the test jars and exposed for different periods. Most of the tests were paired, and the tests were made on different days with different lots of flies. The flies were taken from two similar laboratory strains. Except for a few tests with females alone, equal numbers of male and female flies were used in each test. The residue was usually a half-day old and never more than 3 days old when tested. After exposure the insects were removed to clean holding jars, and the percentage down on their backs after periods ranging from 15 minutes to 4 hours was recorded. A 20-hour mortality count was also made. The jars were re-treated after they had been used for two exposures. The tests were made at room temperature of approximately 72° F., and the flies were held over night at 68° and a relative humidity of 50 per cent.

The mosquitoes, which were tested in a similar manner, were held overnight at 78° F. and a relative humidity of 75 per cent.

To determine whether the sample of technical methoxychlor being used was fully effective, two of the tests were made with a recrystallized sample of this insecticide. To make sure the type of preparation used did not affect the results, some of the tests were made with an emulsion of methoxychlor.[1]

Results.—Table 1 shows that at the 20-mg. dosage the knock-down of flies exposed to DDT and dichlorodiphenyl dichloroethane for 1 minute was low after 15 minutes but increased rapidly during the next 4 hours. Methoxychlor did not cause considerably higher knock-down than DDT or dichlorodiphenyl dichloroethane in 1 minute. However, regardless of the exposure time, many flies revived in 4 hours and the 20-hour mortality was always much less than the 15- and 30-minute knock-down; the flies began to recover 1 to 4 hours after they were exposed.

A 20-minute exposure to the residue

[1] An aralkyl polyether alcohol, *Triton X-100*, with xylene was the emulsifier.

Table 1.—Knock-down and mortality of house flies and Aëdes floodwater mosquitoes exposed to residues of different insecticides.

Insecticide	Exposure (Minutes)	House Flies (Average of 16 Tests with 20 to 25 Flies)					Mosquitoes (Average of 5 Tests with 15 to 20 Mosquitoes)				
		Per Cent Knock-Down in—				Per Cent Kill in 20 Hrs.	Per Cent Knock-Down in—				Per Cent Kill in 20 Hrs.
		15 Min.	30 Min.	1 Hr.	4 Hrs.		15 Min.	30 Min.	1 Hr.	4 Hrs.	
		Dosage 1 mg. per square foot[1]									
DDT	20	8	10	29	46	84					
	1	0	0	0	0	4	0	31	82	82	83
		Dosage 20 mg. per square foot									
DDT	1	27	62	79	90	99					
Dichlorodiphenyl dichloroethane	1[2]	35	53	73	86	86	0	5	24	32	21
Methoxychlor	1	38	49	47	36	31	0	2	17	19	21
	5	71	75	64	57	61	11	36	64	52	55
	10	90	90	85	81	81	50	57	65	68	64
	15	97	97	95	93	94	73	82	81	84	86

[1] Average of 6 tests for flies.
[2] Average of 2 tests.

from a 1-mg. dosage of DDT was slightly less effective than a 1-minute exposure to a 20-mg. dosage. The residue from a 20-mg. dosage of methoxychlor killed 94 per cent of the flies exposed for 15 minutes, whereas a similar DDT residue killed 99 per cent of the flies exposed for only 1 minute. It appears, therefore, that to obtain a mortality of near 100 per cent at this dosage flies must rest or crawl at least 15 times longer on methoxychlor than on DDT. A 1-minute exposure of flies to residues of DDT, dichlorodiphenyl dichloroethane, and methoxychlor applied at the 20-mg. dosage showed that DDT was approximately three times as toxic as methoxychlor and only slightly more toxic than dichlorodiphenyl dichloroethane.

In another series of tests it was observed that flies exposed to methoxychlor exhibited tremors and uncoordinated movements very similar to those produced by DDT. However, the methoxychlor-treated flies would recover nearly 100 per cent from rather violent tremors, whereas the DDT-treated flies would have a low

Table 2.—Knock-down and mortality of house flies exposed to DDT and methoxychlor residues applied at various dosages. Average of 6 paired tests; 35 flies per test.

Exposure (Minutes)	Dosage (Mg. per Sq. Ft.)	Per Cent Knock-Down in—				Per Cent Kill in 20 Hrs.
		15 Min.	30 Min.	1 Hr.	4 Hrs.	
		Methoxychlor				
1	20	30	51	43	34	36
	40	41	55	60	45	46
	80	53	65	60	50	52
5	20	77	82	84	72	69
	40	80	87	89	81	79
	80	85	89	93	89	85
10	20	92	96	98	95	94
	40	91	95	99	98	98
	80	86	91	100	100	100
		DDT				
1	2	4	9	17	37	63
	4	3	13	21	57	89
	8	23	49	66	81	98
5	2	9	25	30	59	85
	4	13	33	47	79	96
	8	41	59	79	92	98
10	2	24	35	45	74	92
	4	35	53	57	88	98
	8	71	88	93	99	100

recovery from mild tremors. This difference was determined by exposing flies to methoxychlor until they showed distinct tremors and nervousness and then by placing them in clean holding cages for study of recovery. The same was done with DDT, except that the transfer was made at the earliest indication of slight symptoms.

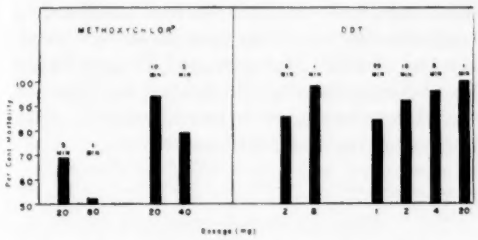

FIG. 1.—Dosage-time relationship of house flies exposed to various residues of DDT and methoxychlor.

The knock-down of mosquitoes exposed to methoxychlor residues (20-mg. dosage) increased gradually between the 15-minute and the 4-hour reading, and the 20-hour mortality was always greater than the 15-minute knock-down. These results are exactly the opposite of those obtained with flies. After an exposure of 1 minute DDT was about four times as toxic to mosquitoes as methoxychlor. A 15-minute exposure to methoxychlor caused 86 per cent mortality, whereas a 1-minute exposure to DDT caused 83 per cent mortality. Therefore, on a glass surface, the mosquito must remain on methoxychlor 15 times as long as on DDT to achieve a similar mortality.

The data in table 2 show another comparison of the effects of DDT and methoxychlor residues on house flies. The flies were exposed to dosages of 20, 40, and 80 mg. of methoxychlor per square foot or to 2, 4, and 8 mg. of DDT. Exposure periods were 1, 5, and 10 minutes in all cases. At a 1-minute exposure methoxychlor was not nearly so effective as DDT even though 10 times as much methoxychlor was used. The same trend was evident with a 5-minute exposure; however, when the exposures were for 10 minutes the mortalities were almost identical, regardless of the dosage. At the 10-minute exposure, therefore, ten times the dosage of methoxychlor was required to produce the same mortality as DDT. The data also show that at any given exposure a fourfold increase in dosage did not considerably increase the mortality of flies. For example, at a 1-minute exposure the mortality at 20 mg. was 36 per cent while at 80 mg. it was 52 per cent with methoxychlor. The results with DDT followed the same trend.

Figure 1 shows that a short exposure of flies to a high dosage of methoxychlor was not so effective as a long exposure to a low dosage. Just the reverse was true with DDT. A 1-minute exposure to 80 mg. of methoxychlor gave 52 per cent mortality whereas a 5-minute exposure to 20 mg. caused 69 per cent mortality; a 5-minute exposure to 40 mg. gave 79 per cent mortality, and a 10-minute exposure to 20 mg. gave 94 per cent. With DDT a 1-minute exposure to 8 mg. gave 98 per cent mortality and a 5-minute exposure to 2 mg. gave 85 per cent mortality. A 5-minute exposure to 4 mg. caused 96 per cent mortality, whereas a 10-minute exposure to 2 mg. caused only 92 per cent. A 1-minute exposure to 20 mg. gave 99.7 per cent kill.

SUMMARY.—At the same dosage rates (20 mg. per square foot) house flies had to be exposed 15 times longer to methoxychlor than to DDT to achieve a 95 per cent mortality. At varying dosages and exposure times it was found that DDT was approximately 10 times as toxic as methoxychlor. At lower dosages many flies recovered after they were exposed to methoxychlor.

LITERATURE CITED

Lindquist, Arthur W., H. G. Wilson, H. O. Schroeder, and A. H. Madden. 1945. Effect of temperatures on knock down and kill of houseflies exposed to DDT. JOUR. ECON. ENT. 38(2): 261–4.

Relationship Between Knockdown and Survival Time for DDT-Poisoned Flies and Roaches

J. Franklin Yeager and Sam C. Munson, *U.S.D.A., Agr. Res. Adm. Bureau of Entomology and Plant Quarantine*

Concentration-survival time curves for roaches injected with some inorganic insecticides, reported previously by the authors (1945, 1947), were found to exhibit a region of inflection, in which a lower injected concentration of a poison was more toxic than a higher one. Since the mode of action of DDT has engaged the attention of a number of physiologists, the question arose as to whether or not a DDT concentration-survival time curve might also exhibit a region of inflection.

An attempt was made to obtain satisfactory curves for roaches injected with corn-oil solutions, but the experimental error was greater than desired, possibly because of the viscosity of the corn oil. Therefore, a semiquantitative procedure was devised for applying known concentrations of DDT in corn oil externally to the dorsal thorax of flies by means of a wire loop, and more satisfactory results were obtained. These data are reported chiefly because they suggest a point of interest relative to the mode of action of DDT.

Method.—Different concentrations of DDT (m.p. 108.5–109° C.) in corn oil were prepared by successive dilutions of a stock solution with the oil. Precautions were taken to ensure thorough mixing of the oil and the stock solution. In the experiments performed first, the mixtures were stirred vigorously and at length with a glass rod. Later mixing was accomplished more satisfactorily by repeatedly drawing the fluid into a tuberculin syringe, without needle attached, and violently expelling it.

Large nymphs of the American cockroach, *Periplaneta americana* (L.), were weighed individually. Injections into the hemolymph were made through the coxa-femoral joint of a leg by means of a Dutky-Fest injector (Dutky 1942). The insects were kept individually in glass vials, closed with wire gauze, at 27° C. and 40 to 80 per cent relative humidity, without food or water. Each roach received approximately 0.023 ml. of oil or DDT-oil solution per gram of body weight. The controls were injected with corn oil only. The injected roaches were examined at suitable intervals for symptoms of toxicity and death (Munson and Yeager 1945). In the experiment illustrated in figure 1, A, 10 roaches were injected with a given concentration of DDT solution.

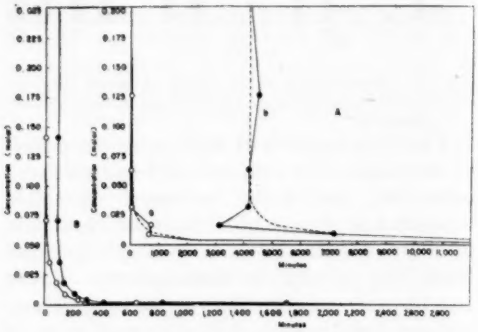

Fig. 1.—Concentration-survival time (solid dots) and concentration-knockdown time (circles) for (A) cockroach nymphs injected with DDT in corn oil and for (B) adults of the house fly poisoned individually with the same material applied to the dorsal thorax.

In the experiments with flies, adults of the house fly, *Musca domestica* L.,[1] were chilled in a refrigerator until the last flies to succumb had just become immobile, whereupon they were put on the surface of ice and the DDT solution was applied at once. A fly was lifted with forceps from the ice by a wing and held, feet down, on a support covered with clean tissue paper, while approximately 0.5 mg. of a DDT solution was placed upon its dorsal thorax by means of a small, calibrated-wire loop. The controls were treated with the same amount of corn oil only. After treatment, the flies, still immobilized by the cold, were placed in 600-ml. glass beakers. When 10 flies receiving a single concentration were in a beaker, the beaker was covered with a loosely woven cloth (organdy), held in place by a rubber band, and a wad of cotton saturated with skim

[1] Obtained from W. A. Gersdorff and J. H. Fales.

milk diluted half and half with water was placed on the cloth cover.

It was not practicable to attempt to prevent contact of the treated thoracic surface of a fly with the inner surface of the beaker. In spite of such uncontrolled variables, however, the method yielded surprisingly consistent data.

Both the roaches and the flies were considered to have been knocked down when they first showed a *permanent* loss of equilibrium, and were considered dead when they failed permanently to respond to mechanical stimulation. Individual knockdown and survival times were measured from the moment of injection of each roach and, for flies, from the moment of application to the last fly of a group receiving the same concentration.

RESULTS AND DISCUSSION.—Concentration-survival time and concentration-knockdown time curves were plotted from the same data of an experiment. One pair of curves for roaches is shown in part in figure 1, A, where the observed points are connected by straight lines. The concentration-knockdown curve (a) is fairly regular, but the observed points of the survival-time curve (b) show considerable variation. Whether this variation is due to random experimental error or represents an actual trend of the curve cannot be determined definitely from the data at hand. If the variation is considered to be caused by random error, the dotted lines on the graph suggest that in the concentrations above about 0.03 *M* the two curves may be separated by an approximately constant time interval. The same thing is suggested by a similar pair of curves obtained in a repetition of this experiment with roaches but not shown in this paper.

Figure 1, B, shows a typical pair of curves obtained from flies treated externally with DDT solutions in corn oil. The times for 50 per cent knockdown (KD_{50}) and 50 per cent mortality (D_{50}) and the differences (Δ) between these values are given in table 1. All four experiments indicate approximately a constant time interval between the knockdown and death caused by the higher concentrations of DDT. This interval is shown in figure 1, B, and table 1 for concentrations above about 0.0044 *M*. In table 1, the time values for the difference between knockdown and death (Δ) are greater below about 0.0023 *M*. Because the intervals between observations are greater for these longer survival times, the data fail to show whether this increase is real or only apparent.

Table 1.—Survival time (D_{50}), knockdown time (KD_{50}), and differences (Δ) between these times for house flies treated externally with different concentrations of DDT in corn oil.

CONCENTRATION (MOLAR)	KD_{50}	D_{50}	Δ
	Minutes	*Minutes*	*Minutes*
0.2821	5	85	80
.1411	7	95	88
.07053	9	95	86
.03526	40	112	72
.01763	90	140	50
.008815	154	214	60
.004408	242	302	60
.002204	300	425	125
.001102	649	839	190
.0005515	1706	1706	0
Controls	—	>7000	—

Another experiment therefore was performed to obtain an answer to this question. A greater number of concentrations of DDT were used, and the intervals between observations were kept small throughout the range of concentrations, except for 0.00125, 0.000625, and the controls. The results are given in table 2, which shows also the period, beginning at the time the first insect of a group was knocked down or killed, within which 50 per cent of the flies were knocked down or had died; this period of time is indicated in the two columns of table 2 under "period."

These data indicate that, when an allowance is made for considerable fluctuation due to random experimental error, the time difference (Δ) between knockdown and death is approximately constant for all concentrations down through 0.0025 *M*. (The original data suggest that at this concentration the frequency distribution of individual survival times might be bimodal; for the apparent lower subgroup, consisting of six insects, the difference between the arithmetic means of the individual times of knockdown and of death is 93 minutes.) Below this concentration the knockdown and survival-time curves approach each other more and more closely, and their time difference becomes less, until eventually the two curves virtually coincide.

The values of Δ for the concentrations below 0.0025 *M* are less exact than the

other Δ values partly because of the longer intervals between observations; but at these lower concentrations the insects were not killed by the DDT and the values for KD_{50} and D_{50} are approximately the same at these low concentrations as for the controls. A tabulation of the values for Δ obtained in all the experiments with flies indicates that, although the values show considerable random variation, no marked trend takes place as concentration changes. These results indicate, therefore, that, within the limits of error of this method, the difference between time of knockdown and time of death of the flies is approximately constant over the lethal-concentration range.

Table 2.—Observed and calculated survival times, times for knockdown, differences Δ between these times, and observation intervals for house flies treated externally with DDT in corn oil.

Concentration (Molar)	Period		KD_{50}		D_{50}		Δ[1]			
	KD_{50}	K_{50}	Observed	Calculated	Observed	Calculated	50%	AM	HM	M
0.200	1	7	8	4	99	110	91	89	79	90
.150	1	7	10	5	82	111	72	90	81	84
.100	4	10	9	8	115	114	106	116	101	111
.075	0.5	10	11	10	119	116	108	118	109	118
.050	4	10	16	15	112	121	96	105	99	98
.0375	4	10	20	21	126	127	106	121	101	123
.0250	3	10	35	32	149	138	114	123	117	118
.0200	3	10	41	40	152	146	111	112	113	117
.0150	4	15	33	55	172	161	139	138	156	126
.0100	6	15	76	87	188	193	112	131	127	118
.0075	7	15	109	122	284	228	175	127	134	150
.0070	10	15	129	133	227	239	98	91	132	90
.0060	10	15	142	161	275	267	133	97	120	146
.0050	30	30	405	205	525	311	120	109	185	105
.0025	60	30	873	652	948	758	75	56	162	67
.0020	—	—	—	11,538	—	11,644	—	—	—	—
.00125	1200	480	8530	—	8560	—	(30)	(5)	(48)	(15)
.000625	1050	1050	6645±	—	6645±	—	(0)	(15)	(180)	(0)
Controls	130	130	7257±	—	7257±	—	(0)	(0)	(0)	(0)

[1] The values for Δ were obtained from KD_{50} and D_{50}, which were actual 50 per cent knockdown and kill (50%) or were represented by calculated arithmetic means (AM), harmonic means (HM), or medians (M), as shown at the top of each column.

None of these curves has a region of inflection like that found for roaches injected with inorganic, water-soluble poisons (Munson & Yeager 1945, 1947; and Yeager & Munson 1945a). The absence of such an inflection, however, does not indicate whether the action of DDT in the body of the insect may involve an equilibrium between a toxic and a nontoxic form of the compound analogous to the equilibrium postulated for sodium metarsenite in the roach. It could mean that, in the present work, either no such equilibrium existed or, if it did exist, an inflection fell at concentrations too high or too low to be detected by this method; or it could mean that the equilibrium did not possess those characteristics necessary for the appearance of an inflection in a survival-time curve.

Because of the lack of a region of inflection in these DDT curves, they can be described mathematically by the familiar equation $(t-a)\ (c-c_0)^N=K$, where a, c_0, n, and K are constants (Yeager & Munson 1945a). For both knockdown and death in the five experiments performed with flies, $N=1$, and the following K values hold for the respective experiments: 0.85, 2.0, 2.5, 1.5, and, for the data shown in table 2, 0.75. For knockdown a and c_0 were negligibly small and were set equal to zero, except in one experiment (Table 2) for which $c_0=0.00135$. For survival time c_0 was negligibly small and was set equal to zero, but a had the respective values 83, 110, 100, 80, and (for that in table 2) 106. The knockdown and survival times calculated with this equation, when the appropriate values are used for the constants, yield curves about which the experimentally obtained values fall rather closely, excepting one experiment in which random error apparently was somewhat larger.

The occurrence of a constant time interval between knockdown and death is of

interest with regard to the possible mode of action of DDT in the insect. Other work has shown that DDT, depending on concentration, can produce typical neuromotor symptoms in the insect through an action at sites in the sensory and the motor parts of the peripheral nervous system (Roeder & Weiant 1946, Yeager & Munson 1945b). A suggestion has been made by J. H. Welsh[2] that DDT may become adsorbed at nerve surfaces and may interfere with the normal interaction between the nerve membrane and certain ions in the adjacent body or tissue fluid. It has also been reported that a marked rise in free acetylcholine may take place in a DDT-poisoned roach after it has been prostrated (Tobias *et al.* 1946).

The existence of a constant time interval between knockdown and death seems to indicate that, once the accumulation of DDT at certain tissue sites has attained a particular level, associated with permanent loss of the ability of the insect to maintain equilibrium, the lethal action of the poison may progress independently of the DDT concentration. This might be the case if, at certain sites of action in the nervous system, DDT were accumulated until, after a threshold number of molecules had been taken up, the lethal action takes place at a rate determined by the accumulated DDT molecules, but not by the DDT molecules not present at those sites. An alternative explanation would be that the rate of toxic action at certain nerve sites and the rate of lethal action at the same or at other sites are so related that, regardless of applied concentration within a wide range, they cause death at a constant interval after knockdown.

CONCLUSIONS.—(1) Concentration-survival time curves for house flies, *Musca domestica* L., poisoned with DDT in corn oil, applied to the dorsal thorax by a wire loop, are hyperbolic in form, exhibit no inflection of the kind reported previously for roaches, *Periplaneta americana* (L.), injected with sodium metarsenite dissolved in saline solution, and can be described by the equation $(c-c_0)\,(t-a)=K$, where a, c_0, and K are constants, and c_0 is negligibly small.

(2) The concentration-knockdown time curves for flies are similar in form, exhibit no inflections, and can be described by the same equation when a and c_0 are made negligibly small.

(3) The difference between time for knockdown and time for death is approximately constant in the range of lethal concentration, when allowance is made for random experimental errors.

(4) The constant time difference between knockdown and death suggests that, whereas the toxic action of the DDT leading to knockdown is a function of the applied concentration, once the knockdown stage of poisoning has been reached, the lethal action of the DDT may proceed independently of the concentration of the poison administered.

(5) Less precise data for roaches suggest that these conclusions might apply also to roaches injected with DDT dissolved in corn oil.

[2] Personal communication; also in O.S.R.D. reports.

LITERATURE CITED

Dutky, S. R. 1942. Method for the preparation of spore-dust mixtures of type A milky disease of Japanese beetle larvae for field inoculation. U. S. Bur. Ent. and Plant Quar. Circ. ET-192,

Munson, Sam C., and J. Franklin Yeager. 1945. Concentration survival time relationship for roaches injected with arsenicals. JOUR. ECON. ENT. **38:** 634–42.

Munson, Sam C., and J. Franklin Yeager. 1947. The relation between poison concentration and survival time of roaches injected with sodium and potassium cyanides and potassium ferricyanide. Ent. Soc. Amer. Ann. **40:** 475–88.

Roeder, Kenneth D., and Elizabeth A. Weiant. 1946. The site of action of DDT in the cockroach. Science **103:** 304–6.

Tobias, J. M., J. J. Kollros, and J. Savit. 1946. Acetylcholine and related substances in the cockroach, fly, and crayfish and the effect of DDT. Jour. Cell. and Compar. Physiol. **28:** 159–82.

Yeager, J. Franklin, and Sam C. Munson. 1945a. The relation between poison concentration and survival time of roaches injected with sodium metarsenite. Ent. Soc. Amer. Ann. **38:** 559–600.

Yeager, J. Franklin, and Sam C. Munson. 1945b. Physiological evidence of a site of action of DDT in an insect. Science **102:** 305–7.

The Use of Sleeves for Evaluating Acaricides as Clothing Treatments[1]

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Because of scrub typhus infections (tsutsugamushi disease) during World War II, there was need for effective methods of protecting personnel from chigger mites (Trombiculidae). The objective was an acaricide for the impregnation of clothing that would provide protection against chiggers even after the garment had been laundered many times, and that would be effective after continuous aging, including exposure to sunlight.

The criterion used in the primary screening of the chemicals was the stopping time (time required for complete immobilization) of five chiggers on cloth samples (4 by 4 inches) impregnated at a rate of 2 grams per square foot. Samples with a stopping time greater than 15 minutes were considered ineffective, as chiggers were occasionally observed to attack within that time. The better chemicals were applied to uniforms and tested by subjects in areas of high chigger population (Snyder & Morton 1946; Bushland 1946).

An intermediate step between the stopping-time tests and the uniform tests was needed for further weeding out of the less effective compounds without the expense and difficulty of synthesizing the large quantities needed for full-scale field tests. Tests were made by the present writers to determine whether impregnated jacket sleeves could be substituted for entire uniforms for the preliminary evaluation of the different materials. If so, it would be possible for each subject to test two sleeves simultaneously, both of which could be treated or one left untreated as a check. Such a technique would require fewer subjects and smaller amounts of chemical for each treatment, making possible the testing of new synthetic organic compounds of which only limited amounts are available. The sleeve method would be adaptable for protection studies in the laboratory in addition to providing a method of field testing similar to that of uniforms.

Materials and Methods.—Two series of field tests were made by the sleeve technique. In the first series sleeves and uniforms were treated with 10 test materials and benzyl benzoate, the standard of comparison. All the materials had shown protective value in previous tests with impregnated uniforms (Cross & Snyder 1948). Sleeves treated with 8 of the materials were tested after the sixth and succeeding washings until they failed to give good protection. Those treated with benzyl benzoate, benzene hexachloride, and *x*-trichlorodiphenyl ether, as well as all the treated uniforms, were tested after the second and succeeding washings. In the second series 4 of the compounds used in the first series (benzil, diphenyl carbonate, 2-thenyl salicylate, and benzene hexachloride) were retested on sleeves and uniforms, and several mixtures were tested only on sleeves. The garments were first tested after the sixth and seventh washings, except those treated with 95 per cent gamma benzene hexachloride which were tested after the second washing.

The period between impregnation and the initial testing was 9 or 10 days for those sleeves tested first after the sixth and seventh washings; the other sleeves were ordinarily tested 1 or 2 days after treatment. There was usually an interval of 1 day between washings; however, the second and third washings (series 1) were on the same day.

Sleeves treated with four of the more effective acaricides and benzyl benzoate were subjected to alternate washing and aging under ultraviolet light to simulate sunlight. They were washed on the three consecutive days following treatment and then tested. They were then exposed under an ultraviolet lamp and tested before and after the succeeding washing, until they failed to provide good protection. Washings after the third were 12, 6, 8, 9, and 5 days apart. There were 11 days of ultraviolet aging between

[1] This work was conducted under funds allotted by the National Military Establishment to the Bureau of Entomology and Plant Quarantine. The authors are indebted to B. V. Travis and Carroll N. Smith for advice and suggestions.

the third and fourth washings and 4, 8, 7, and 5 between subsequent washings. The percentage of protection afforded by the sleeves and uniforms was calculated as follows:

$$= 100 - \frac{\text{Number of chigger attachments to subjects wearing treated garments} \times 100}{\text{Number of attachments to subjects wearing untreated garments}}.$$

RESULTS.—In preliminary observations 4 subjects wearing untreated sleeves on both arms introduced 100 chiggers under each sleeve on two consecutive days. At the end of 3 hours 40 per cent were attached and 51 per cent of the chigger attachments occurred on the upper 6 inches of the arm, 34 per cent on the middle portion, and 15 per cent on the lower 6 inches: 47 per cent were attached on the left arm. The percentages of attachments on the 4 men were 58, 40, 39, and 26. In 44 exposures to natural infestations with untreated sleeves the minimum number of attachments recorded was 2, the maximum 257, and the average 90.

Of six sleeves treated with benzyl benzoate two gave 100 per cent protection, two gave better than 95 per cent protection, one 93 per cent, and one afforded no protection after three washings. One of the two sleeves giving complete protection after three washings gave 95 per cent after the fourth washing, whereas the other gave none. In earlier tests two uniforms impregnated with the same material gave 98 and 100 per cent protection after the third washing and no protection after the fourth.

In both series, with three exceptions, sleeves withstood more washings than uniforms treated with the same acaricide. The exceptions were treated with phenyl benzoate, dichlorodiphenyl ether, and *x*-trichlorodiphenyl ether. Both sleeves and uniforms showed benzyl benzoate, technical benzene hexachloride (10 per cent gamma isomer), phenyl benzoate, and *x*-trichlorodiphenyl ether to be inferior to the other compounds, while dichlorodiphenyl ether was inferior on the sleeve tests only. Five of the most effective materials in uniform tests were also most effective in sleeves. Of these materials benzil gave more than 95 per cent protection through 11 washings in 2 sleeves and 1 uniform, and through 10 washings in the second uniform. Uniforms treated with diphenyl carbonate gave better than 95 per cent protection through 8 washings, and sleeves through 9 and 11 washings. 2-Thenyl salicylate provided more than 95 per cent protection through 10 and 12 washings in sleeves, but only through 7 and 8 in uniforms. By both methods *p*-cresyl benzoate gave more than 95 per cent protection through 9 washings. 2-Thenyl benzoate gave better than 95 per cent protection in uniforms after 7 washings and in sleeves through 10. Diphenylnitrosoamine, also an effective acaricide but a material that stains on exposure to sunlight, gave better than 95 per cent protection through 8 washings in sleeves and through 6 in uniforms. In the second series of tests a sleeve treated with gamma benzene hexachloride gave complete protection through 18 washings. Tests with certain mixtures were made concurrently with the tests in series 2. Equal parts of benzil and diphenyl carbonate gave complete protection through 10 washings, equal to the protection of benzil and better than that with diphenyl carbonate in the same series. Equal parts of benzil and 2-thenyl salicylate gave complete protection through 7 washings. This mixture was therefore less effective than benzil but more effective than 2-thenyl salicylate, which was erratic in this series. Equal parts of the three materials were less effective than the individual ingredients, giving 97 per cent protection after the sixth washing and no protection after the seventh.

Sleeves treated separately with benzil, diphenyl carbonate, and 2-thenyl salicylate were more resistant to alternate washing and aging under ultraviolet light than sleeves treated with benzyl benzoate and *p*-cresyl benzoate. These results were similar to those obtained when the same materials were applied to uniforms and exposed to outdoor aging (Cross & Snyder 1948).

SUMMARY.—A method of using impregnated sleeves has been developed as an intermediate step between laboratory and field evaluations of acaricides as clothing treatment for protection against chigger mites. By this method more tests

per man can be carried out, as well as paired tests on each individual. Much less material is required, making possible the testing of new compounds of which limited quantities are available.

Data are given from tests with several compounds that had shown protective value in previous tests in impregnated uniforms. The results with the two methods were very similar.

LITERATURE CITED

Bushland, R. C. 1946. Tests against chiggers in New Guinea to develop a practical field method for impregnating uniforms with dimethyl phthalate for scrub typhus prevention. Amer. Jour. Hyg. **43**(3): 219–29.

Cross, H. F., and F. M. Snyder. 1948. Field tests of uniforms impregnated with mite toxicants: I, Protection studies. JOUR. ECON. ENT. **41**(6): 396–40.

Snyder, F. M., and F. A. Morton. 1946. Chigger repellents—Benzyl benzoate, dimethyl phthalate, and dibutyl phthalate for impregnation of clothing to prevent chigger (mite) attachments. Soap and Sanit. Chem. **22**(11): 133, 5.

Tick Repellent Investigations at Bull's Island, S. C., 1948[1]

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Field tests with selected tick repellents were conducted[2] at Bull's Island, S. C. from late March until the decline of the tick activity the latter part of July. Bull's Island, a part of the Cape Romain Wild Life Refuge, U. S. Fish and Wild Life Service, was selected as the site of the tests because of the natural abundance there of the lone star tick, *Amblyomma americanum* (L.). Facilities of the Fish and Wild Life Service were made available in connection with the work.

The compounds were selected from the best in laboratory screening tests or previous field studies (Smith & Gouck 1946, King 1948) that were available in sufficient quantity for treating uniforms. All the compounds had also shown repellency or toxicity to mosquitoes, mites, lice, or fleas (Smith & Burnett 1948). They were submitted to the U. S. Food and Drug Administration for toxicological tests on laboratory mammals. Some were indicated to be safe for use on skin or clothing, others to be safe only on clothing at certain dosages, and still others to be used with caution. There were a few of which the toxicity was not known when the tests were begun and they were used with caution. Four additional compounds were included at the suggestion of Philip Granett of Rutgers University.

METHODS.—Regulation two-piece army fatigue uniforms of herringbone twill were impregnated with liquid preparations containing repellents at the rate of about 2 grams per square foot of cloth (75 grams to a uniform and one pair of socks). Two uniforms were treated with acetone solutions of 29 compounds and one uniform was treated with similar solutions of 14 others. The uniforms were tested once each week for 3 weeks as nearly as weather conditions permitted, and these are hereinafter called intermittent-wear tests. Other uniforms treated with acetone solutions of 18 of the compounds that gave the best results in these tests were subjected to daily-wear tests. Beginning the day after treatment test subjects wore the uniforms for 12 hours each day, including the time spent in the field.

In a third series uniforms impregnated with emulsions of three of the compounds were compared with those impregnated with acetone solutions. Two of the repellents were also tested as dusts in pyrophyllite. The dusts contained 2.5 per cent of repellent, and were applied at the rate of about 150 grams per uniform. The uniforms in this series were tested in rotation, usually once or twice each week, until they failed to show 90 per cent repellency on two successive days.

Subjects wearing treated uniforms were exposed in tick-infested territory for 1 to 7 hours, the time depending upon the abundance and activity of ticks. In the

[1] This work was conducted under funds allotted by the National Military Establishment to the Bureau of Entomology and Plant Quarantine.

[2] The authors wish to thank the members of the Orlando, Fla., laboratory who took an active part in the testing, and W. V King, who planned much of the study. Formulations of the repellents were made by members of the chemistry section of the laboratory.

Table 1.—Per cent repellency to the lone star tick of uniforms impregnated with different compounds in acetone solutions.

Compound	Intermittent-Wear Tests			Daily-Wear Tests	
		Average per Uniform[1]		Number of Days' Wear	Average Repellency
	Range	First	Second		
Compounds indicated safe for use on clothing or skin					
1. Acetanilide, *N*-ethyl-	32–100	76	99	—	—
2. Benzoic acid, benzyl ester	55– 95	76	84	2	60
3. Benzoic acid, hexyl ester	0– 66	33	—	—	—
4. Bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic acid, *cis*-dimethyl ester (dimethyl carbate)	95–100	97	99	2	90
5. Caproic acid, ester (mono-) with 1,5-pentanediol[2]	86– 89	87	—	—	—
6. Cinnamic acid, isobutyl ester	45– 98	72	80	—	—
7. Cinnamic acid, isopropyl ester	73– 98	82	89	—	—
8. Cinnamyl alcohol	63–100	83	99	2	80
9. Hydracrylic acid, *beta*-phenyl-, ethyl ester	88– 96	94	95	2	74
10. Isobutyric acid, 2-phenoxy-ethyl ester	95–100	100	98	2	42
11. Levulinic acid, benzyl ester	71– 95	86	—	—	—
12. Mandelic acid, hexyl ester	94–100	97	99	2	71
13. Phthalic acid, diethyl ester	55–100	77	100	—	—
14. Phthalic acid, dimethyl ester	79– 95	88	—	—	—
15. 1,3-Propanediol, 2-butyl-2-ethyl-	86– 96	95	91	2	60
16. 1,2*H*-Pyran-6-carboxylic acid, 3,4-dihydro-2,2-dimethyl-4-oxo-, butyl ester (*Indalone*)	84–100	94	96	2	87
17. Succinamic acid, *N*,*N*-dipropyl-, propyl ester	0– 99	35	95	—	—
Compounds indicated safe for use on clothing but not on skin					
18. Acetanilide, *N*-butyl-	100–	100	100	8	92
19. Acetic acid, thiocyano-, fenchyl and isobornyl esters (*Thanite*)	76–100	87	99	2	32
20. Cyclohexanol, 2-phenyl-	96–100	99	98	—	—
21. Diphenylamine[2]	81–100	90	97	—	—
22. Ethanol, 2-[2-(2-ethylhexyloxy)ethoxy]-	72–100	95	91	8	92
23. Hendecenoic acid	94–100	96	99	1	97
24. 4-Morpholineacetic acid, isobornyl ester[2]	75–100	99	90	2	44
25. Phenethyl alcohol, *p*-isopropyl-	65– 98	84	96	—	—
Compounds of undetermined toxicity					
26. Benzoic acid, isoamyl ester[2]	13– 26	20	—	—	—
27. Caproic acid, fenchyl ester	13– 51	32	—	—	—
28. Phthalic acid, dibutyl ester	49– 99	72	83	—	—
29. Acetamide, N-amyl-alpha-butoxy-	90–100	99	96	7	93
30. Bicyclo[2.2.1]-5-heptene-2,3-dicarboximide, *N*-amyl-	99–100	99+	—	—	—
31. Cyclohexanepropionic acid	98–100	98	100	3	85
32. 1,9-Decandien-4,7-diol, 7-methyl-4-(2-propenyl)-	96–100	99	—	—	—
33. Dodecanal	90–100	95	97	5	84
34. Ethanol, 2-(2-hexyloxyethoxy)-	51– 99	64	96	4	76
35. Hendecanal, 2-methyl-	97–100	98	99	4	82
36. Oil of bay[2]	77– 99	88	90	—	—
37. 2-Propanol,1-[1-(3,3,5-trimethylcyclohexyloxy)-2-propoxy]-	96–100	99	98	—	—

[1] The uniform was usually worn on three different days over a period of 2 or 3 weeks.
[2] Irritating to the skin on some occasions.

intermittent-wear tests the bottoms of the trousers and jackets were worn loose, whereas in the other tests the bottom of the jacket was tucked inside the waist band of the trousers and the trouser legs inside the top of the socks. During the exposure period the subjects alternately walked about and sat on the ground, all doing the same thing to give equal exposures. Occasionally it was found necessary to move to a different focus of infestation during a test. After the exposure period the uniforms were left on for 30 to 90 minutes so that the ticks had time to attach or to drop off or die, according to the effectiveness of the chemical.

In the intermittent-wear tests the plan was to have each uniform worn by the

same person each time it was tested, but owing to changing personnel this practice could not always be adhered to. In the other tests different subjects wore the uniforms in successive tests. In each test one untreated uniform was worn as a check.

After the exposure and a short waiting period, the uniforms were removed and all ticks on the clothing or body were counted. Separate records of attached and unattached ticks were kept, but results showed the effectiveness of the chemicals to be about the same whether calculated on the basis of attached ticks only or on the total number.

The results of the tests were expressed as per cent repellency derived from the formula $100\ (N-T) \div N$, in which N is the number on the check and T the number on the treated uniform. A count on the check of at least 15 attached ticks and a total of at least 25 attached and unattached ticks was established arbitrarily as the minimum required for suitable testing conditions. When the infestation on the check dropped below either of these figures, the tests for that period were not included in the evaluation of effectiveness.

RESULTS.—The results of intermittent-wear tests with 37 compounds are summarized in table 1. Nineteen compounds averaged at least 90 per cent repellency in the first three tests, 17 of these on each of two uniforms, and two on a single uniform each. Eight others gave a high average on one uniform but less than 90 per cent on a second one. Two compounds, *Indalone* (No. 16) and 2-[2-(2-ethylhexyloxy)ethoxy]ethanol (No. 22), showed repellency below 90 per cent in individual tests but later tests were well above that. Compounds that were 90 per cent effective on individual uniforms for longer periods (not shown in the table) were as follows: Dimethyl carbate (No. 4) for 24 days; 2-phenoxyethyl isobutyrate (No. 10), 25 days; hexyl mandelate (No. 12), 24 days; *Indalone* (No. 16), 30 days; *N*-butylacetanilide (No. 18), 38 days; 2-phenylcyclohexanol (No. 20), 24 days; 2-[2-(2-ethylhexyloxy)ethoxy]ethanol (No 22), 37 days; cyclohexanepropionic acid (No. 31), 29 days; dodecanal (No. 33), 38 days; 2-methylhendecanal (No. 35), 30 days, and 1-[1-(3,3,5-trimethylcyclohexyloxy)-2-propoxy]-2-propanol (No. 37), 36 days.

The following six compounds (not listed in the table were irritating to the skin of the subjects and were discarded before the first test was completed: Butyl benzoate, ethyl cinnamate, *dl-alpha*-phenylethylamine, *alpha*-(2-butoxyethoxy)-*N*-cyclohexylacetamide, *m*-nitrobenzaldehyde, and ethyl *beta*-benzoylacrylate.

Nineteen of the better compounds in the foregoing tests, which were available in sufficient quantity, were also tested at Camp Bullis, Tex., in cooperation with the Brooke Army Medical Center, as reported by Smith *et al.* (1949).

Table 2.—Comparative effectiveness against the lone star tick of uniforms impregnated with acetone solutions and emulsions of three of the better repellents.

Repellent No.	Weeks After Treatment	Per Cent Repellency			
		Emulsion		Solution	
		Range	Average	Range	Average
4. Bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic acid, *cis*-dimethyl ester (dimethyl carbate)	1	86–100	94	74– 95	88
	2	65– 98	85	96– 96	96[1]
	3	43– 94	72	85– 85	85[1]
	4	51– 94	74	84– 84	84[1]
	5	—	—	68– 78	75
16. 1,2*H*-Pyran-6-carboxylic acid, 3,4-dihydro-2,2-dimethyl-4-oxo-, butyl ester (*Indalone*)	1	47–100	79	81–100	94
	2	66– 96	82	92– 97	94
	3	0– 85	51	89– 97	93
	4	4– 75	40[1]	93– 93[1]	93
	5	—	—	67– 67[1]	67
22. Ethanol, 2-[2-(2-ethylhexyloxy)-ethoxy]-[2]	1	89–100	95	85–100	93
	2	86– 95	93	38– 88	71
	3	82– 95	90	86– 94	91
	4	92– 92	92[1]	96– 96	96[1]
	5	81– 81	81[1]	83– 89	86[1]

[1] 1 or 2 tests only, 3 to 6 in all others.
[2] Irritating to skin of some subjects.

The results of the daily-wear tests (12 hours' wear each day) in which uniforms were impregnated with acetone solutions are also shown in table 1. The infestation rate was particularly high during these tests, and several compounds were less effective at the time of the first test than at any time in the preceding series. Of the 18 compounds tested by this method, only 2-[2-(2-ethylhexyloxy)ethoxy]ethanol (No. 22), *N*-amyl-*alpha*-butoxyacetamide (No. 29), and *N*-butylacetanilide (No. 18) were 90 per cent effective for 3 to 5 days. Although each of these compounds had one or two failures (below 90 per cent repellency) during the period of testing, the repellency was higher in subsequent tests with the same uniforms. Four compounds, 2-(2-hexyloxyethoxy)ethanol (No. 34), 2-butyl-2-ethyl-1,3-propanediol (No. 15), dimethyl carbate (No. 4), and cyclohexanepropionic acid (No. 31) irritated the skin of subjects, but were worn until they failed, Hendecenoic acid (No. 23) was very irritating and the test was terminated before failure.

The results of impregnation tests comparing acetone solutions and emulsions of some of the better repellents are shown in table 2. Emulsions and solutions of 2-[2-(2-ethylhexyloxy)ethoxy]ethanol and dimethyl carbate were about equally effective, whereas solutions of *Indalone* were definitely better. In the dusts *Indalone*, freshly applied, provided more than 90 per cent protection in five of nine tests and 2-[2-(2-ethylhexyloxy)ethoxy]ethanol in six of seven, although the dosage was only 0.1 gram per square foot. The latter caused irritation to the skin of some subjects in all three methods of impregnation.

SUMMARY.—Field tests with selected tick repellents were conducted at Bull's Island, S. C., from March through July 1948. The repellents were applied to regulation army fatigue uniforms and worn in areas heavily infested with the lone star tick, *Amblyomma americanum* (L.).

The more effective compounds that have been indicated safe for use on skin or clothing, and caused no irritation in these tests, were the butyl ester of 3,4-dihydro-2,2-dimethyl-4-oxo-1,2*H*-pyran-6-carboxylic acid (*Indalone*), 2-phenoxyethyl isobutyrate, hexyl mandelate, and ethyl *beta*-phenylhydracrylate. *Indalone* was the most consistently effective, and is readily available commercially.

The outstanding compound on the basis of effectiveness alone was *N*-butylacetanilide, followed closely by 2-[2-(2-ethylhexyloxy)ethoxy]ethanol and *N*-amyl-*alpha*-butoxyacetamide. They were indicated safe for use on clothing at least at 2 grams per square foot but both were very toxic when applied directly to the skin, and both caused irritation to the skin of some subjects. *N*-amyl-*alpha*-butoxyacetamide was indicated unsafe for use on clothing at 2 grams per square foot. 2-Butyl-2-ethyl-1,3-propanediol and the dimethyl ester of *cis*-bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic acid (dimethyl carbate) were somewhat less consistently effective than the foregoing, but have been indicated safe for use, the former on clothing and the latter by direct application to the skin. Dimethyl carbate caused irritation to the skin in one instance.

Acetone solutions of *Indalone* produced more effective impregnation than emulsions, but both formulations with 2-[2-(2-ethylhexyloxy)ethoxy]ethanol and dimethyl carbate were about equal. Treatment of uniforms with powders of *Indalone* and 2-[2-(2-ethylhexyloxy)ethoxy]ethanol (0.1 gram per square foot) gave fair to good protection for a single wearing.

LITERATURE CITED

King, W. V. 1948. Some results of recent work on the newer insecticides. Amer. Jour. Trop. Med. 28(3): 487–97

Smith, C. N., and D. Burnett, Jr. 1948. Laboratory evaluation of repellents and toxicants as clothing treatments for personal protection from fleas and ticks. Amer. Jour. Trop. Med. 28(4): 599–607.

Smith, C. N., M. M. Cole, E. A. Jones, and J. C. Clark. 1949. Investigations of tick repellents at Camp Bullis, Texas, 1948. JOUR. ECON. ENT. 42(5): 716–720.

Smith, C. N., and H. K. Gouck. 1946. Observations on tick repellents. JOUR. ECON. ENT. 39(3): 374–8.

Comparative Evaluation of Rotenone Formulations for Cattle Grub Control

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In a previous paper Furman & Douglas (1948) reported the results of trials with seven formulations for the control of *Hypoderma lineatum* and *H. bovis*. Of the materials tested only those containing ground rotenone bearing material were found to be effective. Benzene hexachloride, Chlordan and a liquid rotenone extract were ineffective.

The experiments reported herein were designed to extend the previous observations to determine: (1) The effect of a wetting agent on the effectiveness of a rotenone formulation, with and without sulfur; (2) The effect of particle size of sulfur; (3) The role of sulfur in the rotenone formulation; (4) The relationship between rotenone content and effectiveness of control. In addition three formulations containing rotenone and a synergist were tested.

METHODS AND MATERIALS.—Spray applications were made with a power sprayer adjusted to develop 350 to 400 pounds pressure. The various materials were applied to the backs of cattle held in a chute or stanchions with a nozzle producing a course, driving fan-shaped spray which was directed against the lie of the hair from a distance of approximately twelve inches. Approximately 2 quarts of spray were used per animal.

On the seventh day following treatment all grubs that could be extracted were removed from the backs manually, taken to the laboratory, warmed slightly and examined under a dissecting microscope. If no movement was noted in response to tactile stimulation they were classified as dead. The species and stage of development was also recorded. The authors have followed the thesis of Knipling (1935), who established that in the larval development of *Hypoderma* there are only 2 molts and 3 stages instead of 4 molts and 5 stages as previously believed.

The seven day interval between application of the spray and extraction of the grubs was selected largely for convenience. It was realized beforehand, and subsequently established experimentally, that a longer interval would result in somewhat higher mortality figures. The results presented herein are intended as a comparative evaluation of the materials tested and do not indicate the actual degree of control which may be expected under field conditions.

The following materials were used:

(Quantities given are based on 100 gallons of water)

1. Ground derris[2]	10	lb.
2. Ground derris	10	lb.
Sodium lauryl sulfate	48	gm.
3. Ground derris	10	lb.
Sulfur (average particle size 9.3 microns)	10	lb.
4. Ground derris	10	lb.
Sulfur, wettable (average particle size 8.3 microns)[3]	10	lb.
Sodium lauryl sulfate	96	gm.
5. Ground derris	10	lb.
Sulfur (average particle size 5.9 microns)	10	lb.
Sodium lauryl sulfate	96	gm.
6. Ground derris	5	lb.
Sulfur, wettable (average particle size 8.3 microns)[3]	10	lb.
Sodium lauryl sulfate	72	gm.
7. Derris extract equivalent to ground derris of 5% rotenone content	2.5	lb.
Piperonyl butoxide	10	lb.
8. Ground derris	2	lb.
Van Dyk 264[4]	16	oz.
Modified polyglycolester	8	oz.
9. Rotenox (HR Formula P-11)[5]	80	oz.

In the formulations which contained sulfur but no wetting agent the sulfur was wetted by mixing it with water and placing it under a vacuum

DISCUSSION OF RESULTS.—The data obtained in these experiments are summarized in table 1. By inspection the

[1] The authors gratefully acknowledge the aid of Jerzy Neyman, Director of the Statistical Laboratory of the University of California, in setting up the type of analysis to be used; however, the authors accept sole responsibility for the conclusions reached.

[2] All ground Derris contained 5% rotenone.

[3] Contained 1% by weight sulfonated oleic acid ester.

[4] N-octyl bycycloheptene dicarboximide.

[5] Manufacturer's statement of ingredients:

Polymerized rotenone, rotenoids and other cube extractives	4.00%
Hydrogenated rotenone, rotenoids and other cube extractives	.75%
Ethylene glycol ether of pinene	12.25%
Piperonyl cyclohexanone	.25%
Naphthalene derivatives	4.00%
Pine oil	28.00%
Mineral oil, refined	36.75%
Ethylene dichloride	5.00%
2-amino-2 methyl-1 propanol, emulsifier	9.00%

formulae may be divided into those which were effective and those which were ineffective. The effective group includes formulae 1, 2, 3, 4, and 5 which contained 10 pounds of ground derris. Formulae 6, 7, 8 and 9 were considered ineffective.

In order to test the comparative effectiveness of the effective formulae the following hypotheses were erected:

A. Formula 1 is equal in effectiveness to formula 2 (effect of wetting agent on derris)
B. Formula 3 is equal in effectiveness to formula 4 (effect of wetting agent on derris and sulfur)
C. Formula 4 is equal in effectiveness to formula 5 (effect of particle size of sulfur)
D. Formula 1 is equal in effectiveness to formula 3 (effect of sulfur without wetting agent)
E. Formula 2 is equal in effectiveness to formula 4 (effect of sulfur with wetting agent)
F. Formulae 1, 2, 3, 4, and 5 are equally effective against *H. lineatum* and *H. bovis*.

The above hypotheses were tested statistically using the modified X^2 method previously employed. The formula used in testing hypotheses A through E was as follows:

$$X^2=\frac{N_1(q1.^2-q..^2)+N_2(q2.^2+q..^2)}{q..(1-q..)}$$

where

N = Number of grubs collected for a given application

$q1.$ and $q2.$ = proportion killed for a given application

$$q..=\frac{N_1q1.+N_2q2.}{N_1+N_2}.$$

Testing hypothesis A, which stated essentially that the presence of a wetting agent did not affect the efficiency of a rotenone spray, it is found that the observed difference in results would occur by chance only three times in a hundred trials. The hypothesis is therefore rejected and the presence of a wetting agent is considered to have significantly increased the effectiveness of the ground derris.

Hypothesis B is similar to A except that the effectiveness of the wetting agent was measured in the presence of sulfur. The probability value for this comparison indicates that the observed difference in results would occur by chance less than one time in a thousand trials. There is a possibility that the increased effectiveness of formula 4 in this case was due to the additional wetting agent (45 grams of sulfonated oleic acid ester) present in the wettable sulfur. However this is not substantiated by the results of hypothesis C. (see below).

Since it is well known that particle size plays an important part in the toxicity of many insecticides, it was considered desirable to determine if the particle size of sulfur played any part in its toxicity to cattle grubs. To accomplish this, hypothesis C was established in which formula 4, containing sulfur with an average particle size of 8.3 microns, was compared with formula 5, containing sulfur with an average size of 5.9 microns. The probability value for this comparison indicates that the difference observed could occur by chance 40 per cent of the time. It is concluded, therefore, that within the range tested the particle size of sulfur did not influence the effectiveness of the formulations. It should be noted that in formula 4 the sulfur contained 45 grams of sulfonated oleic acid ester while the sulfur in formula 5 contained no wetting agent. This amount of wetting agent in addition to the 96 grams of sodium lauryl sulfate present in both formulae apparently did not influence the observed results.

Stewart (1945), Bishopp *et al.* (1944) and others have recommended the addition of sulfur to the rotenone spray formulation for cattle grub control. Weaver *et al.* (1946) did not recommend sulfur in the spray formulation but included it in a dipping formulation. Shull *et al.* (1945) on the other hand, recommended that sulfur not be employed in the spray formulation and stated that sulfur may reduce the effectiveness of the formulation. In order to determine if sulfur increased the effectiveness of rotenone two hypotheses were erected. The first, D, states that formula 1, ground derris, is equal to formula 3, ground derris plus sulfur. The probability value for this comparison indicates the differences observed were due to chance and would be expected to occur 20 times in a hundred trials. The second hypothesis, E, compares the effectiveness of formula 2, ground derris plus wetting agent, with formula 4, ground derris plus sulfur plus wetting agent. The probability value for this comparison indicates the difference

Table 1.—Results with rotenone sprays for cattle grub control.

No.	Formula (Based on 100 Gal. Water)		Animals Treated	Third Stage Grubs Collected					
				Hypoderma bovis		*Hypoderma lineatum*		Totals	
				Collected	Kill	Collected	Kill	Collected	Kill
1	Ground Derris	10 lbs.	91	111	29%	100	69%	211	48%
2	Ground Derris Sodium lauryl sulfate	10 lbs. 48 gm.	54	98	48	74	72	172	58
3	Ground Derris Sulfur (9.3 microns)	10 lbs. 10 lbs.	88	107	33	41	61	148	41
4	Ground Derris Sulfur (wettable, 8.3 microns) Sodium lauryl sulfate	10 lbs. 10 lbs. 96 gm.	90	56	46	69	78	134	63
5	Ground Derris Sulfur (Baghouse, 5.9 microns) Sodium lauryl sulfate	10 lbs. 10 lbs. 96 gm.	41	112	48	36	86	148	57
6	Ground Derris Sulfur (wettable, 8.3 microns) Sodium lauryl sulfate	5 lbs. 10 lbs. 72 gm.	84	142	15	137	50	279	32
7	Extract equiv. to Derris Piperonyl butoxide	2.5 lbs. 10 lbs.	33	69	9	65	15	134	12
8	Ground Derris Van Dyk 264 Mod. polyglycolester	2 lbs. 16 oz. 8 oz.	20	41	7	18	33	59	15
9	Rotenox-HR Formula P-11	80 oz.	85	162	8	217	5	379	6
	Untreated			23	0	19	5	42	2

observed was also due to chance, and would be expected to occur 45 times in a hundred trials. Hypotheses D and E are therefore accepted and it is concluded that sulfur does not influence the effectiveness of a rotenone spray formulation, either in the presence or absence of a wetting agent.

Bishopp *et al.* (1926) noted that *Hypoderma bovis* appeared to be more resistant to insecticides than *H. lineatum*. This was also pointed out by the authors in a previous paper, Furman & Douglas (1948). To confirm these findings hypothesis F was established, which states that the effective formulae (1, 2, 3, 4, 5) are equally effective against third stage *H. lineatum* and *H. bovis*. The X^2 formula for this computation is as follows:

$$X^2 = \sum_{i=1}^{5} \sum_{j=1}^{2} nij \frac{(qij - q..)^2}{q..(1-q..)}$$

where

i = insecticide formulation
j = species of *Hypoderma*
n = number of grubs collected

The probability value for this hypothesis shows that the observed result was not due to chance. Only once in 1000 trials would a difference as great as that observed occur by chance alone. Therefore the data reported here confirm the finding that *Hypoderma bovis* is more resistant to insecticides than is *H. lineatum*.

Bishopp *et al.* (1944) and others have recommended 5 pounds of derris containing 5 per cent rotenone in 100 gallons of water as an effective control for cattle

grubs. The results obtained in this investigation do not support this recommendation. From the figures presented in the table it is apparent that a comparable formula containing 10 pounds of derris resulted in nearly a 100 per cent increase in effectiveness over the formula containing 5 pounds of derris. Since, in a previously reported investigation by the authors (1948), there was demonstrated to be no clear-cut evidence of the superiority of 10 pounds of derris over 7.5 pounds, it would appear that the lower limit which will yield maximum efficiency falls between 7.5 and 5 pounds. The results with 5 pounds were comparatively so poor it would not seem desirable to reduce the dosage appreciably below 7.5 pounds.

Recent interest in the development of pyrethrum and rotenone activators or synergists such as piperonyl butoxide and N-octyl bicycloheptene dicarboximide led to the trials with formulae 7, 8, and 9. From the results obtained (Table 1) it is apparent that these materials did not significantly increase the effectiveness of the rotenone. It appears that the efficiency of these formulae was proportional to the rotenone content.

SUMMARY AND CONCLUSIONS.—1. The presence of a wetting agent significantly increased the effectiveness of ground derris and ground derris plus sulfur formulations.

2. The particle size of sulfur, within the range 5.9 to 8.3 microns, did not affect the efficiency of the formulation.

3. Sulfur did not significantly increase the effectiveness of the derris formulation.

4. Derris of 5 per cent rotenone content when used at the rate of 5 pounds to 100 gallons of water was approximately half as effective as a 10 pound dosage.

5. Piperonyl butoxide and N-octyl bycycloheptene dicarboximide did not increase the efficiency of rotenone.

LITERATURE CITED

Bishopp, F. C., E. W. Laake, H. M. Brundrett, and R. W. Wells. 1926. The cattle grubs or ox warbles, their biologies and suggestions for control. U. S. Dept. Agr. Bull. **1369.**

Bishopp, F. C., E. W. Laake, and R. W. Wells. 1944. Cattle grubs or heel flies with suggestions for their control. U. S. Dept. Agr. Farm . Bul. **1596.**

Furman, Deane P., and James R. Douglas. 1948. Comparative evaluations of insecticides for cattle grub control. JOUR. ECON. ENT. **41**(5): 783–7.

Knipling, E. F. 1935. The larval stages of *Hypoderma lineatum* de Villers and *Hypoderma bovis* De Geer. Jour. Parasitol. **21**(2): 70–82.

Shull, W. E., H. C. Manis, and Glenn C. Holm. 1945. Grubs and Lice on Cattle. Univ. Idaho Ext. Bul. **155.**

Stewart, M. A. 1944. Rotenone and ox warble control. JOUR. ECON. ENT. **37**(6): 756–60.

Weaver, S. G., James J. O'Connell, and G. I. Gilbertson. 1946. Spraying cattle insects. South Dakota State Col. Ext. Leaf. **102.**

ENTOMOLOGISTS IN THE ARMY

Recent permanent promotions of entomologists in the Regular Army: Herbert C. Barnett, 1st Lieutenant to Captain; Franklin S. Blanton, Major to Lt. Colonel; Stanley J. Carpenter, Major to Lt. Colonel; Joseph M. Geary, 1st Lieutenant to Captain; Hugh L. Keegan, 1st Lieutenant to Captain; Walter J. LaCasse, Captain to Major; and Frederick W. Whittemore, Captain to Major.

Major Ralph W. Bunn is attending a nine-month course at the School of Public Health, University of California, at Berkeley.

Captain Herbert C. Barnett was transferred to the 406th Medical General Laboratory, Far East Command, in April, 1949 to conduct research on insect vectors of Japanese B encephalitis.

Major Robert Traub returned in February, 1949 from a three-month tour of duty in Malaya where he assisted in field tests of the new antibiotic, chloromycetin.

Lt. Colonel Franklin S. Blanton returned to Alaska in April, 1949, for his second summer tour of duty as Military Liaison Officer of the Alaska Insect Control Project.

Captain Carl R. Bruck returned from foreign duty in the Far East Command in January, 1949 and is now assigned to the 6th Army Area Laboratory at Fort Baker, California.

Lt. Colonel Emory C. Cushing was assigned to the Medical Field Service School, Fort Sam Houston, Texas, in February 1949.

Control of a Salt Marsh Tabanid by Means of Residual DDT-Oil Spray

BERTRAM I. GERRY, *Massachusetts Department of Agriculture*

Because a salt marsh greenhead fly, *Tabanus nigrovittatus* (Macquart), constitutes a real threat to the normal expansion of seashore recreational centers and summer colonies located along the Massachusetts coast line, the Massachusetts General Court, during its 1946 session, enacted special legislation authorizing a greenhead fly investigation for the North Shore. This investigation was initiated during the late summer of 1946 and continued through 1947 and 1948. The purpose of the investigation was twofold: (1) to acquire general information relative to the life history and habits of this salt marsh tabanid, and (2) to utilize the information gained in the first phase of the investigation as a basis for the formulation of control measures. In 1949, following the completion of the investigation, greenhead fly control projects were organized in three adjoining towns located on the South Shore of Massachusetts Bay.

LARVAL DISTRIBUTION.—Larval collections were taken periodically over a 2-year period. All collections taken from thatch drift, deposited along the inner edge of the marsh, showed a preponderance of last instar larvae. Those taken during January provided evidence that last instar larvae winter within 2 inches of the marsh surface. Collections taken during July and August from algal mats, located along the banks of the lateral ditches close to the upland, and from the wet central portions of marsh depressions, contained a high percentage of second instar larvae. It was evident that larvae hatching in the vicinity of the ditches migrate to higher elevations as they mature, while those hatching in wet depressions migrate to the less moist periphery. The following larval distribution table indicates that migrating larvae tend to concentrate in that section of the marsh reached only by high course tides.

ADULT EMERGENCE.—A study of adult emergence was conducted to establish the date of peak fly production. A few adults were observed in flight during the last week in June—the population then increased rapidly and peak production was well established by the end of the second week in July. Abundant fly production continued for about 3 weeks and then fell off sharply. By the end of the second week in August adults were scarce although a few persisted into September. The population counts (number of flies taken in 5 minutes from a parked car with front windows open) were made in the Pine Island control area located in Newbury. The full line graph (Fig. 1) illustrates: (1) the rapid build-up of the population during the first two weeks in July; (2) the extended period during which a dense population prevails; and (3) the sharp fall in fly population immediately following the end of peak production.

There was no evidence to indicate a direct physiological relationship between the high course tides and fly emergence.

Table 1.—Summary of larval collections of *Tabanus nigrovittatus*. (100 collections in each of six Zones, 50 feet wide.)

AREAS SAMPLED	ZONE I 0 TO 50	ZONE II 50 TO 100	ZONE III 100 TO 150	ZONE IV 150 TO 200	ZONE V 200 TO 250	ZONE VI 250 TO 300
Pine Island	439	84	81	203	105	16
Scituate	234	92	19	15		
Marshfield	233	36	41			
Duxbury	164	82	53	21		
Totals	1070	294	194	239	105	16

Each collection represents number of larvae taken from 1 square yard of marsh surface.
The inner 300 ft. strip of marsh, adjacent to the upland, was divided into six 50 ft. zones for collecting purposes.
High counts, in zones IV, V and VI at Pine Island resulted from presence of two small knolls located within 300 ft. of the upland.

However, certain observations did indicate the tendency of high course tides to flush flies from the marsh. This caused the periods of high course tides and those of severe fly nuisance to coincide.

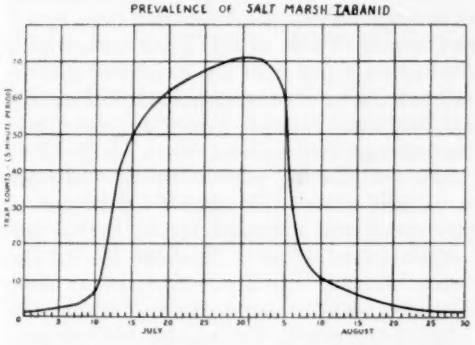

FIG. 1.—The prevalence of the salt marsh tabanid, July and August.

DESCRIPTION OF TEST AREAS.—Ipswich Beach, on the North Shore, is backed immediately by a strip one-half mile in width composed of sand dunes. In the rear of the dunes an extensive salt marsh area, more than two miles in width, supports a dense population of *Tabanus nigrovittatus*. A focal point was selected at the center of the beach and all salt marsh within one mile of this point was staked out for treatment. Since the flies return to the marsh at dusk or whenever weather conditions became unfavorable for flight, the sand dunes within a mile of the beach were not treated. At Wingaersheek Beach, also on the North Shore, the Salt marsh is located immediately in the rear of the beach. Both beach and salt marsh are flanked on the west by a series of wooded knolls and on the east by the Annisquam River and the town. In preparing this area, a focal point was established at the beach center, after which all salt marsh lying within one-half mile of the focal point was staked out in preparation for spraying.

DESCRIPTION OF CONTROL AREA.—The South Shore control area comprised all salt marsh in the three adjoining coastal towns of Duxbury, Marshfield and Scituate. The control area involved a 15-mile section of coast line which possessed a total of 4460 acres of fly-producing salt marsh. The marsh is not continuous, but is concentrated at the river mouths and in the vicinity of the several harbors. The variation in marsh elevations provided an opportunity to study fly production under different marsh conditions. On the higher, well-drained marsh, larvae were numerous in patches of dead grass located 100 feet or more from the upland. On the lower, water-saturated marsh, larvae were scarce except at the marsh fringe where thatch had been deposited by the extreme high tides. Larval collections indicated that, where salt marsh extended for 2 to 3 miles up-stream from the river mouths, the heavy larval infestations were located in the vicinity of the river outlets. The collections showed also that larvae were scarce along the inland reaches of the marsh where a bracksih condition exists.

EQUIPMENT AND MATERIALS.—The spraying equipment used on the North Shore test plots consisted of a PT-17 airplane with boom and 29 nozzles adjusted to distribute 2 gallons of spray per acre. The spray was mixed on the field as follows: to each 55 gallon drum containing 37.5 gallons of xylene was added 150 lbs. of DDT (technical grade), giving a total of 50 gallons by volume and 3 lbs. of DDT per gallon of solution. In loading the airplane, 20 gallons of the DDT-xylene solution were first placed in the airplane insecticide tank, then 40 gallons of No. 2 fuel oil added by pumping the oil directly from a tank truck through an extension hose to the insecticide tank of the airplane. The pay load of 60 gallons then contained 60 lbs. of DDT, or 1 lb. of DDT to each gallon of spray. When the spraying operations had been completed, the 280 acres at Ipswich had received 527 gallons of spray or a dosage of 1.77 lbs. of DDT per acre. The 140 acres at Wingaersheek Beach had received 238 gallons of spray or a dosage of 1.60 lbs. of DDT per acre. Aluminum stearate, at the rate of 1 per cent by weight, was added to the spray material used at Wingaersheek Beach: (1) to ascertain its value in reducing loss of active ingredients by penetration of the foliage (Ebeling 1945); and (2) to establish its value as a spreader.

Additional equipment consisting of several wooden frame cages (8 inches by 8 inches by 14 inches) with solid bottoms, the remaining surfaces being covered with 16-mesh mosquito screen and the tops hinged to allow access to the interiors. these cages were constructed for testing the residual effect of the spray. About 75

microscope slides, treated with magnesium oxide smoke, were used in determining the value of aluminum stearate as a spreader.

Spraying equipment used for the South Shore control program of 1949 consisted of a helicopter fitted out with boom and nozzels. The spray contained equal parts of: (1) commercial 25 per cent DDT concentrate and (2) No. 2 fuel oil. These two ingredients were delivered to the insecticide tanks of the helicopter through separate lines. Two days previous to spraying operations, aluminum stearate was added to the 25 per cent DDT concentration in quantity sufficient to provide 1 per cent by weight of the finished spray. Two 100-foot swaths were applied along the inner margin of the salt marsh at the rate of 1 gallon of spray per acre, or 1 lb. of DDT per acre. The first application (July 11 and 12) was followed by a second application ten days later (July 21 and 22). The spraying program involved treatment of 1500 acres or approximately one-third of the entire salt marsh acreage.

DISCUSSION.—The test areas, at Ipswich and Wingaersheek Beaches on the North Shore, were treated to provide information relative to the barrier width necessary for reasonable protection of individual recreational areas. The single application applied to these test plots (July 16 and 17) indicated that a half-mile treated barrier would serve to trap migrating flies and would provide a 90 per cent reduction of greenheads in such recreational areas throughout the period of peak fly production. In a series of cage tests, flies were exposed to marsh grass from both test areas The cage tests showed that at Ipswich Beach, where aluminum stearate was omitted from the spray formula, the residual value was lost in less than 12 days, while at Wingaersheek Beach, where 1 per cent by weight of aluminum stearate was included in the spray formula, the residual effect persisted well beyond the twelfth day. The magnesium-coated slides, distributed over the Wingaersheek Beach experimental plot before spraying began, showed that 1 per cent by weight of aluminum stearate added to the spray increased the coverage 10 times on smooth surfaces.

On the basis of information acquired during the North Shore investigation, the South Shore control project was organized to include two applications, ten days apart at the rate of 1 lb. of DDT per acre, which contained 1 per cent by weight of aluminum stearate. It was anticipated that two applications would provide protection throughout the entire period, (July 12 to August 5) during which the fly nuisance is usually severe. Because 94 per cent of the specimens included in the larval collections were taken within 200 feet of the inner margin of the marsh, only two 100-foot swaths were applied along the edge of the marsh during the 1949 control program. Comparisons of adult collections taken before and after spraying operations (marsh sweepings and car counts) indicated a 95 per cent reduction in the salt marsh greenhead fly population.

SUMMARY.—Studies of the salt marsh greenhead fly life history showed that adult emergence begins during the last week in June and continued through July and August in Massachusetts.

Larval collections showed that 94 per cent of the fly larvae are located on that portion of the salt marsh which lies within 200 feet of the upland.

Reasonable adult control was attained at individual recreational areas with DDT-oil solution applied at the rate of 1.7 lbs. of DDT per acre to all salt marsh within a half-mile of the area, at the beginning of peak fly production.

Control throughout the entire season over a 15-mile section of shore line was acquired with two applications of DDT-oil spray containing 1 per cent by weight of aluminum stearate. The spray was applied at the rate of 1 gallon per acre and was equivalent to 1 lb. of DDT per care.

When aluminum stearate was added to the DDT-oil spray, in the proportion of 1 per cent by weight, it prolonged the residual effect and substantially increased the coverage.

LITERATURE CITED

Ebeling, Walter. 1945. DDT Penetration Prevented by Adding Aluminum Stearate to DDT-Kerosene Solution. JOUR. ECON. ENT., 38(2): 289–91.

Effect of Temperature on Knockdown and Mortality of House Flies Exposed to Residues of Several Chlorinated Hydrocarbon Insecticides

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The effect of temperature on the knockdown and mortality of insects exposed to insecticides is of considerable practical importance. For several years it has been known that on some insects DDT is more effective at relatively low temperatures than at high temperatures. Lindquist *et al.* (1945, 1946) demonstrated that this was true of house flies, mosquitoes, and bedbugs, and Richards & Cutkomp (1946) obtained their greatest kill of mosquito larvae, *Aëdes aegypti* (L.), at low temperatures. Fan *et al.* (1948) demonstrated in the laboratory that low concentrations of DDT were more effective on mosquito larvae exposed at low temperatures than at high, and named this relationship a negative temperature coefficient.

From a practical standpoint it appears that house flies are controlled with low dosages of DDT in northern or cool climates. For example, the states of Washington and Oregon have recommended a wettable-powder spray containing only 0.5 per cent of DDT for residue spraying in barns. Because only 3 to 6 ml. of fluid can be applied on a vertical wood surface before run-off, the dosages used ranged from 15 to 30 mg. of active ingredient per square foot. According to extension workers these dosages have given good control. In comparison, the southern states recommend a dosage of 200 mg. per square foot for satisfactory control.

The present article gives the results of laboratory tests made recently at Corvallis, Oregon, to determine the effect of temperature on the speed of knockdown and mortality of house flies, *Musca domestica*, (L.) exposed to several chlorinated hydrocarbon insecticides. The tests were made at constant temperatures of 70° and 90° F., and the relative humidity ranged from 40 to 60.

SPEED OF KNOCKDOWN TESTS.—In the speed of knockdown tests, petri dishes, 90 mm. by 17 mm., were evenly coated on the inside with acetone solutions of the insecticide to be tested. Covers made of 16-mesh screen wire greatly minimized the effect of fumigation. Approximately 20 flies, 3 to 6 days old, half males and half females, were used per test. The tests were made simultaneously at the two temperatures with flies of the same age and from the same source. The flies were exposed continuously and were considered down when they were on their backs and unable to crawl or fly.

The results of these tests are given in table 1. DDT, dichlorodiphenyl dichloroethane, and methoxychlor caused faster knockdown at 70° F. than at 90° or, in other words, had a negative temperature coefficient. All the other compounds, except benzene hexachloride, knocked down the flies consistently faster at 90° than at 70°. Essentially the same results were obtained when the tests were repeated and pint jars instead of petri dishes were used as the test containers.

Benzene hexachloride produced erratic results, sometimes showing a positive and sometimes a negative temperature coefficient. Apparently the concentration of the chemical is the determining factor. Fumigation no doubt plays an important part in the effectiveness of this compound. Therefore, additional tests were made in which two jars were treated at the rate of 2.5 mg. per square foot. One of the jars was capped to retain the fumes, and the air in the other was withdrawn continuously by means of a ventilating fan in a hood. Two hours after treatment and at a temperature of 90° F. flies exposed in the capped jar were knocked down in 15 minutes and in the ventilated jar in 28 minutes. The 100- and 200-mg. dosages used in the petri-dish tests (Table 1) caused some fumigation and therefore showed a positive temperature coefficient.

The effectiveness of the materials cannot be compared precisely because of differences in the dosages and in the ages of the residues. However, at the high temperature parathion, heptachlor, and

Table 1.—Effect of temperature on speed of knockdown of house flies exposed continuously to residues of various insecticides in petri dishes. Average of 3 to 4 tests.

Chemical	Dosage per Square Foot (Milligrams)	Minutes Required for Knockdown at		Temperature Coefficient
		70° F.	90° F.	
DDT	200	18	17	—
	1	82	229	
Methoxychlor	1	56	151	Neg.
Dichlorodiphenyl dichloroethane	5	203	337	
	3	127	360(60)[1]	
Heptachlor	200	68	28	
	50	65	35	
Parathion	50	21	10	
	3	35	17	•
Chlordane	50	100	63	Pos.
Dieldrin[2]	100	142	52	
	50	61	45	
Benzene Hexachloride	200	53	26	
(12.8 per cent gamma)	100	75	37	
	50	47	47	—
	5	360(3)[1]	360(13)[1]	—
	3	360(66)[1]	360(43)[1]	Neg.
Toxaphene	200	237	89	
	50	299	191	Pos.
Aldrin[3]	200	87	37	
Test compound 153[4]	200	135	50	
Untreated Check	0	—	—	—

[1] Figures in parentheses indicate per cent of flies down in 360 minutes.
[2] 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonaphthalene. (Julius Hyman Co.).
[3] 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene. (Julius Hyman Co.).
[4] Composition of compound not disclosed by manufacturer. (Julius Hyman Co.).

benzene hexachloride (high dosage) appeared to be the most effective. At the low temperature parathion, DDT, heptachlor (high dosage), and benzene hexachloride (high dosage) were the most effective.

(Mortality Tests)—The mortality studies were conducted in wide-mouth pint jars treated in the same way as the petri dishes. Several dosages and exposure times were employed (Table 2). The containers treated with the 0.25-mg. dosage were re-treated 2 hours before each test. At the higher dosages they were re-treated every 5 to 7 days. Heptachlor was used at 0.125 mg. per square foot because fresh treatments at higher dosages consistently caused 100 per cent kills. At the low dosage a fresh treatment gave good kills but day-old or aged residues gave poor kills. Approximately 35 flies were introduced into each screen-capped test jar.

Table 2.—Effect of temperature on mortality of house flies after short exposure to residues of insecticides. Average 3 to 5 tests.

Chemical	Dosage Per Square Foot (Milligrams)	Length of Exposure (Minutes)	Per Cent Mortality in 24 Hours of Flies Exposed and Held at—	
			70° F.	90° F.
DDT	5	5	87	64
Methoxychlor	5	15	86	54
Dichlorodiphenyl dichloroethane	5	15	88	33
Heptachlor	0.125	1	41	94
Parathion	0.25	5	36	93
Chlordane	0.25	10	76	98
Dieldrin[1]	0.25	2	86	98
Benzene Hexachloride (12.8 per cent gamma)	0.25	10	68	67
Toxaphene	5	20	58	79
Untreated Checks	0	24 hours	2	5

[1] Julius Hyman Co.

The flies were exposed for predetermined periods of time (1 to 20 minutes), after which they were removed to clean containers, fed and watered, and held for 24 hours at the same temperature at which they were exposed.

The results of the mortality studies are given in table 2. Various exposure times and dosages were tested before the 24-hour mortalities were brought below the 100 per cent level. DDT, dichlorodiphenyl dichloroethane, and methoxychlor consistently showed better results at 70° F. than at 90°. All the other compounds, except benzene hexachloride, gave the best results at 90° and therefore exhibited a positive temperature coefficient. Benzene hexachloride caused equal mortalities at both temperatures, possibly because of lack of fumigation at the low dosage used. Similar results were obtained in additional tests in which petri dishes instead of jars were used as the test containers.

As in the speed of knockdown tests, the effectiveness of the compounds cannot be compared closely because of the different dosages, exposure times, and ages of residues. However, at the low dosage of 0.25 mg. per square foot, parathion, chlordane, dieldrin, benzene hexachloride, and heptachlor (0.125 mg.) caused, in general, better results than DDT, dichlorodiphenyl dichloroethane, methoxychlor and toxaphene, even though the last compounds were tested at a dosage 20 times as great as the others.

SUMMARY.—The effect of temperature on speed of knockdown and mortality of house flies exposed to residues of several chlorinated hydrocarbons was determined by exposing house flies (1) continuously at constant temperatures of 70° and 90° F. and (2) for predetermined periods (1 to 20 minutes) at 70° and 90° and then holding them for 24 hours at the same temperature at which they were exposed.

DDT, dichlorodiphenyl dichloroethane and methoxychlor consistently gave faster knockdown of house flies at 70° F. than at 90°. These compounds also caused greater mortality at the low temperature than at the high temperature. The reverse was true with heptachlor, parathion, chlordane, dieldrin and toxaphene.

LITERATURE CITED

Fan, H. Y., T. H. Cheng, and A. G. Richards. 1948. The temperature coefficients of DDT action in insects. Physiol. Zool. **21**(1): 48–59.

Lindquist, A. W., H. G. Wilson, H. O. Schroeder, and A. H. Madden. 1945. Effect of temperature on knockdown and kill of houseflies exposed to DDT. JOUR. ECON. ENT. **38**(2): 261–4.

Lindquist, A. W., A. H. Madden, and H. O. Schroeder. 1946. Effect of temperature on knockdown and kill of mosquitoes and bedbugs exposed to DDT. Kans. Ent. Soc. Jour. **19**(1): 13–15.

Richards, A. G., and L. K. Cutkomp. 1946. Correlation between the possession of a chitinous cuticle and sensitivity to DDT. Biol. Bul. **90**: 97–108.

Effect of Air Temperature on the Insecticidal Action of Some Compounds on the Sheep Tick and on Migration of Sheep Tick on the Animal

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Several workers have found that insecticides vary in their effectiveness according to temperatures. Lindquist *et al.* (1945, 1946) showed that DDT residual sprays caused more rapid knockdown and kill of mosquitoes and house flies at low than at high temperatures. Potter & Gillham (1946) obtained higher mortality of adult grain beetles at low than at high temperatures after spraying with DDT solutions. Richards & Cutkomp (1946) found the same to be true with larvae of *Aëdes aegypti* (L.) mosquitoes. Temperature and other climatic conditions no doubt also play an important role in the effectiveness of the newer chlorinated hydrocarbon insecticides on many insects. Therefore, laboratory tests were made during the winter of 1948–49 to determine whether these insecticides performed differently in winter than in summer on the sheep tick *Melophagus ovinus* (L.), as was

indicated in previous field tests. The results of these tests, as well as of studies on sheep tick migration, are given in this paper.

Woolen cloth patches, 3.75 inches in diameter, were impregnated with acetone solutinos of the technical compounds except benzene hexachloride at the rate of 24 mg. of active ingredient per square foot. The benzene hexachloride, which contained 12.8 per cent of the gamma isomer, was applied at 6 mg. per square foot. After drying for several hours the cloth patches were placed in the bottom of 100-mm. petri dishes and at least 10 ticks were exposed on each cloth approximately 2 hours. The length of exposure was varied in some tests so as to have a mortality of less than 100 per cent. Tests were made at temperatures of 70° and 90° F.

The sheep ticks were collected from sheep 1 to 3 hours before they were placed in the test, and appeared to be about 60 to 70 per cent females. After exposure the ticks were removed to a clean dish and held at a constant temperature, identical with that prevailing at exposure.

Table 1 shows that DDT, methoxychlor and dichloridiphenyl dichloroethane caused considerably higher mortality of sheep ticks at 70° F. than at 90°, and that the reverse was true with toxaphene, benzene hexachloride, and chlordan.

Because of the variations in exposure times, the effectiveness of the insecticides cannot be compared precisely. At a constant temperature of 70° F. DDT appeared to be superior to the other compounds. At 90°, however, DDT, methoxychlor, and dichlorodiphenyl dichloroethane gave mortalities of 40 to 46 per cent, whereas toxaphene and chlordan caused 94 and 98 per cent kill and benzene hexachloride, at one-fourth the dosage, 62 per cent kill. The mortalities in the untreated checks were always greater at 90° than at 70°. However, even when the 20 per cent mortality of the checks is considered, it is clear that toxaphene, chlordan, and benzene hexachloride are much more effective than the other compounds. The data presented graphically in figure 1 makes use of Abbot's formula. This formula is frequently used for making adjustments for high mortalities obtained in untreated checks, such as occurred with these tests at 90° F. The formula is as follows:

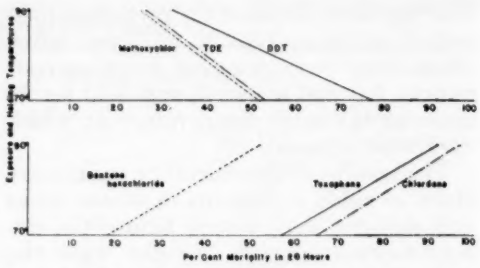

FIG. 1.—Effect of temperature on the insecticidal action of some compounds on the sheep tick.

$$\frac{\text{Per cent alive in checks} - \text{Per cent alive in treatments}}{\text{Per cent alive in checks}} \times 100$$

OPTIMUM TEMPERATURES FOR SHEEP TICK MIGRATION.—Because of the significant differences in mortalities obtained with some of the insecticides, it is important to know the temperatures of wool and the optimum temperatures sought by the sheep tick. Sheep ticks are known to migrate to the outer wool during warm spring weather, and also during warm days in the fall. Air temperatures probably play an important role in this migration, and to obtain further information on this subject two tests were made in which heavily infested sheep were subjected to fluctuating temperatures and the movements of ticks were studied. Two animals with a fleece length of 4 inches were used in these tests. Each animal was brought into a room and placed in a standing position on a table. Two observers, one on either side of the animal, counted the ticks on the outside wool at 5- or 10-minute intervals.

The first test was made by gradually raising the temperature from 40° F. to about 90° in 140 minutes, and counting the ticks on the outer wool surface of an 80-pound lamb (predominantly Hampshire) at 10-minute intervals during this period. In 30 minutes, at an air temperature of 61°, 41 ticks were counted. After 1 and 2 hours the air temperatures were 75° and 87° and the number of ticks totaled 63 and 115, respectively. After 140 minutes (temperature 90°) the number of ticks recorded was 110. The total tick population on the animals had been determined previously by parting the wool and carefully counting all the ticks on one side of the animal and doubling

Table 1.—Mortality of sheep ticks exposed at 70° or 90° F. and then held at the same temperature for 20 hours. Average of 4 to 7 tests.

CHEMICAL	DOSAGE PER SQUARE FOOT (MILLIGRAMS)	LENGTH OF EXPOSURE (MINUTES)	PER CENT MORTALITY AT—	
			70° F.	90° F.
DDT	24	120	77	56
Methoxychlor	24	120	52	40
Dichlorodiphenyl dichloroethane	24	120–210	53	41
Toxaphene	24	120	57	94
Benzene hexachloride (12.8 per cent gamma)	6	30–120	18	62
Chlordane	24	120	65	98
Untreated checks (14 tests)			1	20

the count obtained. The maximum number of ticks that appeared on the wool surface (115) at any one time during the temperature test, represented 41 per cent of the total ticks on the animal. During the test period the skin temperatures rose from 93° to 101°, and the wool temperatures 1 inch from the surface from 71° to 87°. The above test was repeated twice with essentially the same results.

For the second test a 75-pound lamb was brought into a heated room (87° F.) from an outside temperature of 31°. Within the first 5 minutes 52 ticks appeared on the surface of the wool. In about 1 hour the number had increased to 97, or approximately 46 per cent of the total number of ticks on the animal. As in the previous test, the total population, approximately 210, was determined by carefully counting the ticks on one side of the animal. During the test period the skin temperatures rose from 93° to 100° and the wool temperatures (1 inch from skin) from 69° to 91°. This test was repeated 3 times with approximately the same results.

When the animals used in these tests were brought outside to air temperatures of 30° to 40° F., the ticks retreated very quickly into the wool. The location of ticks invariably has been observed to be on the skin of sheep at air temperatures below about 35°. At higher air temperatures some of the ticks may be located on the skin and others at various distances away from the skin. In the field occasional ticks have been observed on the outer wool surface at air temperatures of 58° to 65°, but usually the temperature must be 70° or above before many are observed.

The importance of these migrations in sheep tick control by means of sprays is obvious. Sprays do not usually penetrate to the skin, and therefore during cold periods ticks do not come in contact with the treated wool. Furthermore, as the wool grows there is an untreated zone adjacent to the skin. It is possible that wetting agents might improve the penetration of the spray. Spray tests conducted in the early fall showed good control in 6 weeks' time but poor control in another 2 months' time. The poor control was attributed to emerging adults, which do not come in contact with sprayed wool because cold air temperatures keep them close to the skin.

TEMPERATURES IN WOOL.—To obtain information on temperatures in wool, studies were conducted under varying conditions and on different sheep with fleece lengths of 3 to 5 inches. Temperatures were taken at three locations on the animals—the back, throat, and ribs. At each location the bulb of the thermometer was placed 0.25 inch from the outer wool surface, 1 inch above the skin, and directly on the skin. While the temperatures were being taken the animal was usually allowed to stand in the shade so that circulation of air currents was not impeded.

Table 2 shows that temperatures on the skin varied from 88° F. at air temperatures of 16° to 22° to 102° at an air temperature of 76°. Skin temperatures on the throat averaged higher than those on the ribs or back. The temperatures at the skin were always higher than those at the other locations. Although the migration of ticks may be influenced by factors other than air temperatures, it is evident from these tests that ticks migrate away from the skin at air temperatures of about

Table 2.—Effect of air temperature on wool temperature at the throat, ribs, and back of a sheep.

Air Temperature (° F.)	Number of Tests	Part of Body Tested	Temperatures in Wool (° F.)		
			On Skin	1 Inch Above Skin	¼ Inch From Outer Surface
16–22	3	Throat	90	73	58
		Ribs	88	74	59
		Back	84	73	61
		Average	88	73	59
25–26	2	Throat	94	72	62
		Ribs	92	74	62
		Back	88	71	60
		Average	81	72	61
37	3	Throat	93	75	62
		Ribs	91	74	64
		Back	86	71	63
		Average	90	73	63
58–60	2	Throat	98	89	79
		Ribs	97	89	80
		Back	96	88	79
		Average	97	89	79
72–76	2	Throat	102	94	88
		Ribs	101	95	85
		Back	102	97	89
		Average	102	95	87

65° to 80° and stay close to the skin at air temperatures below 65°.

DISCUSSION.—On the basis of these studies it is believed that the best control of sheep ticks will be obtained when sprays are applied during the warm season of the year, or when ticks are moving away from the skin. Chlordane, benzene hexachloride, and toxaphene will probably be more effective than DDT, dichlorodiphenyl dichloroethane and methoxychlor under these conditions.

SUMMARY.—In laboratory tests many more sheep ticks, *Melophagus ovinus* (L.), were killed at 70° F. than at 90°. when exposed to wool treated with DDT, methoxychlor, and dichlorodiphenyl dichloroethane. The reverse was true with toxaphene, benzene hexachloride, and chlordan. The sheep tick remains on the skin of sheep at air temperatures of about 35° and below, but may be found a short distance from the skin at higher temperatures. At 80° to 90° many of the ticks are on the outer wool surface. In control of the sheep tick by means of sprays, it is important to take advantage of outward migration of ticks. This can be done by spraying during the warmer seasons of the year.

LITERATURE CITED

Lindquist, A. W., A. H. Madden, and H. O. Schroeder. 1946. Effect of temperature on knockdown and kill of mosquitoes and bedbugs exposed to DDT. Jour. Kansas Ent. Soc. **19**(1): 13–5.

Lindquist, A. W., H. G. Wilson, H. O. Schroeder, and A. H. Madden. 1945. Effect of temperature on knockdown and kill of houseflies exposed to DDT. JOUR. ECON. ENT. **38**(2): 261–4.

Potter, C., and E. M. Gillham. 1946. Effects of atmospheric environment, before and after treatment, on the toxicity to insects of contact poisons. Ann. Appl. Biol. **33**: 142–59.

Richards, A. G., and L. K. Cutkomp. 1946. Correlation between the possession of a chitinous cuticle and sensitivity to DDT. Biol. Bul. **90**: 97–108.

Effect of Curly Top-Infective Beet Leafhoppers on Cantaloup Plants

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Curly top has long been recognized as a major problem on sugar beets in the territory west of the Rocky Mountains. The relationship of the beet leafhopper, *Circulifer tenellus* (Bak.), to the disease was reported by Ball (1906). Severin (1928) published a list of host plants of curly top among which were listed seven species and numerous varieties of plants in the Cucurbitaceae family, including muskmelons, cantaloups, and honeydews. He described curly top disease symptoms for some members of the cucurbit family, but made the statement that muskmelons and cantaloups experimentally infested with curly top showed no reliable symptoms. Observations by the senior author over a period of 10 years in the Salt River Valley of Arizona indicated that curly top may be present in cantaloups and yet not produce reliable or even recognizable symptoms. The importance of curly top to the production of cantaloups in this area is therefore not clearly understood.

The beet leafhopper, which is the only known vector of the curly top virus, breeds on various weeds throughout southern Arizona and is known to infest cantaloup fields. Specimens of cantaloup plants suspected of containing the curly-top virus were gathered from commercial cantaloup plantings in the Salt River Valley and submitted to N. J. Giddings, of the Bureau of Plant Industry, Soils, and Agricultural Engineering, at Riverside, Calif. In many instances Giddings (1948) recovered curly top virus from these plants. As a supplement to field observations, experiments were started during the spring and summer of 1948 to determine the effect of the feeding of infective beet leafhoppers on cantaloup plants in varying stages of development. Experiments completed so far have been only with plants in the cotyledon and two-leaf stages of development.

EXPERIMENTAL PROCEDURES.—Cantaloup plants used in these experiments were of the variety known as Powdery Mildew Resistant No. 45, which is the most common variety grown in the Salt River Valley. Two types of experiments were conducted, as follows: (1) Plants in either cotyledon or two-leaf stage were experimentally exposed to 6 to 15 infective beet leafhoppers for 1 week; (2) individual plants in the cotyledon stage were exposed to one such leafhopper for 24 hours. Infective beet leafhoppers used in these experiments were from colonies reared on encaged sugar beets severely affected with curly top.

For infesting plants with several leafhoppers cylindrical cages 4 inches in diameter and 8 inches tall were used. The sides of these cages were covered with a fine-mesh cotton scrim and the top was made of celluloid. For infesting plants with one leafhopper, glass-vial leaf-clip cages were used. These cages consisted of a section of glass tubing 1 inch long and 0.875 inch in diameter covered on top with bolting cloth and held in place on a portion of a leaf against a glass microscope slide by means of rubber bands.

Plants used in each of the experiments were selected for uniformity and were staked in pairs. A random plant of each pair was experimentally infested with leafhoppers, while the other was used as an uninfested check. Weekly observations were made on the appearance and development of the plants. In some of the experiments differences between treatments were obvious and consistent. In other experiments, where differences were not so pronounced or consistent, plant measurements were taken. Plant height and later the length of the main runner, as well as the average diameter of fully extended leaves, were used as criteria in determining differences between treated and untreated plants. In some tests the number of leaves per plant was also considered. The resulting data were analyzed by the analysis of variance for randomized blocks.

[1] The authors wish to acknowledge the informal cooperation of N. J. Giddings, of the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, who has made helpful suggestions during the progress of this work and has supplied curly-top-infective leafhoppers from which colonies were started. They also acknowledge the cooperation of the University of Arizona in making available cantaloup plots for some of the work.

FIELD TESTS.—These experiments were conducted during April and May 1948, on cantaloups grown on the University of Arizona Salt River Valley Vegetable Research Farm at Tempe, Ariz. Twenty-two hills consisting of 2 to 4 plants each in the cotyledon stage of development, were selected for one series of tests. Cages were placed only over the plants to be infested and 10 infective leafhoppers were introduced into each. Cages were removed in 1 week, at which time all leafhoppers were dead. Differences between the plants were obvious at that time, the plants that had been infested being definitely retarded in growth and development as compared with the others. At the 2- and 3-week examination periods these differences became even more pronounced. Figure 1, 7*A* and 7*B* shows the appearance of one

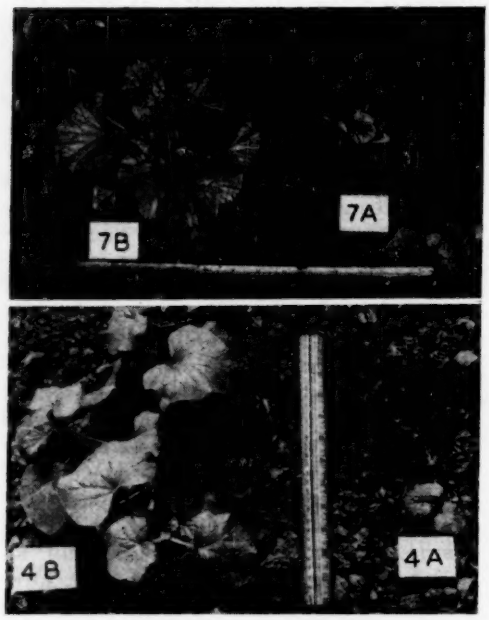

FIG. 1.—Damage to cantaloup plants 3 weeks after they had been infested in the cotyledon stage with several curly top-infective beet leafhoppers for 1 week: 7, *A*, Infested plant in the field; 7, *B*, plant comparable to 7, *A* but not infested; 4, *A*, infested plant in shade plot; 4, *B*, plant comparable to 4, *A* but not infested.

of the replicates 3 weeks after introduction of leafhoppers. Although all the plants that had been infested were either killed or much stunted, as indicated in figure 1, no symptoms developed which could be readily identified as curly top. Some of the plants showed a slight yellowing, but usually there was little difference in color.

A second experiment was conducted on the Salt River Valley Vegetable Research Farm at Tempe with cantaloup plants in the two-leaf stage of development. Thirty-two plants were selected and cages were placed over 16. Six infective leafhoppers were introduced into each cage and allowed to remain 1 week, at which time all leafhoppers were dead and the cages were removed. No differences could be seen between the plants at that time nor at the 2-week examination period. Between 2 and 3 weeks after inoculation the stakes were accidentally knocked down in cultivating and no further observations were possible.

EXPERIMENTS UNDER LATH SHADE.—Further studies were made during the summer and fall months on a small plot under lath shade in the rear of the laboratory. In these experiments infested and uninfested plants were caged alike in order to avoid any possible bias due to cage effect.

In one experiment the plants were in the cotyledon stage and there were 12 hills of 4 plants each. Six hills were each infested with 15 infective leafhoppers, the other 6 being maintained insect-free as checks. At the end of 1 week surviving leafhoppers were killed by spraying with tetraethyl pyrophosphate and the cages removed. At that time all the plants that had been infested were noticeably retarded in development, as compared with the others. After 2 weeks the differences were more pronounced, and 3 weeks after leafhopper introductions, all the plants that had been infested were either dead or drastically stunted, as shown in figure 1, 4*A* and 4*B*. After 4 weeks only 2 of the original 24 infested plants remained alive. Twenty-two of the insect-free plants were still alive and had an average runner length of 25 inches. Although most of the plants that had been infested died within 4 weeks, the symptoms that developed could not be clearly identified as due to curly top.

In another experiment 12 cantaloup plants in the two-leaf stage of development were encaged. Fifteen infective leafhoppers were introduced into each of six cages. After 1 week the cages were removed and the infested plants were sprayed with tetraethyl pyrophosphate,

although most of the insects were dead. No differences could be seen in the plants at the time nor after 2 weeks. Table 1 gives the average length of the main runner for the infested and uninfested plants 3, 5, and 7 weeks after infestation and the average leaf diameter of each group after 5 weeks. None of the plants that had been infested in this experiment were killed, but all were retarded in development. One of the insect-free plants stopped growing after 2 weeks, presumably owing to curly top infection from some outside source.

In a third experiment under lath shade in the laboratory plot, glass-vial clip-cages were attached to one leaf of each of 26 cantaloup plants in the cotyledon stage of development. One infective leafhopper was placed in each of 13 of the cages. After 24 hours the cages were removed by clipping off that portion of leaf within the cage. No differences could be seen in the plants 1 week after infestation but the infested plant in one replicate

Table 1.—Damage to cantaloup plants in the two-leaf stage due to feeding of 15 infective beet leafhoppers for 1 week.

Time After First Application	Average Length of Main Runner		Average Leaf Diameter	
	Infested	Not Infested	Infested	Not Infested
Weeks	*Inches*	*Inches*	*Inches*	*Inches*
3	12	20	—	—
5	20[2]	61	2.8[1]	4.2
7	22[2]	73	—	—

[1] Significantly less than for uninfested plants with odds of 19:1.
[2] Significantly less than for uninfested plants with odds of 99:1.

was dead, and therefore the replicate was discarded. None of the other plants died during the 5-week period of observation. Plants that had been infested were retarded in growth in 7 of the 12 replicates after 2 weeks and in 9 after 3 weeks. As shown in table 2, the average differences in growth became greater with the age of the plants. Figure 2 illustrates the plants in paired replicates Nos. 7 and 8, 5 weeks after inoculation. Plant No. 7 *A* was so stunted that it had made very little growth since the four-leaf stage of development; 6 of the 12 infested plants were thus affected. Plant No. 8 *A* was retarded in growth, but otherwise appears normal; 3 of the 12 infested plants were thus

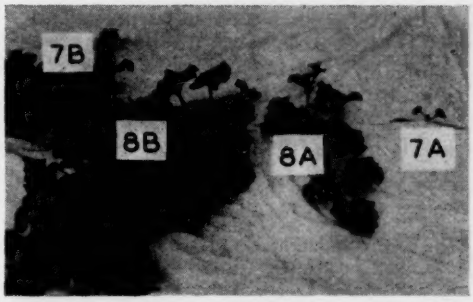

FIG. 2.—Damage to cantaloup plants under shade 5 weeks after being infested for 24 hours in the cotyledon stage with one infective beet leafhopper: 7, *A* and 8, *A*, plants infested for 1 day; 7, *B* and 8, *B*, comparable plants not infested.

affected. In the other 3 replicates there were no differences between infested and uninfested plants.

Table 2.—Damage to cantaloup plants in the cotyledon stage due to feeding of one infective leafhopper for 24 hours.

Time After Infestation	Average Length of Main Runner		Average Leaf Diameter		Average Leaves per Plant	
	Infested	Not Infested	Infested	Not Infested	Infested	Not Infested
Weeks	*Inches*	*Inches*	*Inches*	*Inches*	*Number*	*Number*
2	2.8[1]	3.4	1.8[1]	2.3	3.2	3.8
3	3.7[2]	4.9	2.1[2]	3.1	5.0[2]	7.7
5	10.6[2]	20.2	2.7[2]	4.3	12.3[1]	22.6

[1] Significantly less than for uninfested plants with odds of 19:1.
[2] Significantly less than for uninfested plants with odds of 99:1.

SUMMARY AND CONCLUSIONS.—Experiments were conducted to determine the effect of curly top on young cantaloup plants. Beet leafhoppers, *Circulifer tenellus* (Bak.), known to be curly top infective were encaged on cantaloup plants of the variety known as Powdery Mildew Resistant No. 45 in the cotyledon and two-leaf stages of plant development. Groups of leafhoppers encaged on the plants in the cotyledon stage of development for 1 week resulted in either drastic stunting or eventual death of every plant. All plants infested in the two-leaf stage of development were retarded in growth, but none was killed and the retardation of growth was not so drastic as with plants infested in the cotyledon stage.

In experiments on the feeding of one infective leafhopper for 24 hours on plants in the cotyledon stage, some of the plants were severely stunted, whereas others did not appear to be affected.

The results of these experiments indicate that cantaloup plants of the variety tested developed some resistance to the curly top virus between the cotyledon and two-leaf stages of development. Some cantaloup plants in the cotyledon stage apparently tolerated the feeding of one infective leafhopper over a period of 24 hours. No symptoms characteristic of curly top developed in any of the experiments, although some inoculated plants were either retarded in growth, drastically stunted, or killed.

LITERATURE CITED

Ball, E. D. 1906. The beet leafhopper (*Eutettix tenellus* Bak.). Utah Agr. Expt. Sta. Ann. Rpt. **16**: 16.
Giddings, N. J. 1948. Curly top of muskmelons. Phytopathology **38**(11): 934–6.
Severin, H. H. P., and C. F. Henderson, 1928. Some host plants of curly top. Calif. Agr. Expt. Sta. Hilgardia **3**(13): 368–77.

Control of the Sand Wireworm in Louisiana

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The sand wireworm, *Horistonotus uhlerii* (Horn.) is perhaps the most destructive soil inhabiting insect on Louisiana. The known range of its distribution in Louisiana is in the northern part of the state, chiefly in the hilly, sandy soils of Bienville, Red River, Bossier, and Union parishes. Until 1947 this species was not considered as occurring in bottom lands. However, in the summer of 1947, extensive areas in the bottom lands along the Red River in Bossier parish were found to be heavily infested with it. The soils where these infestations occur contain a high percentage of sand.

The first experiments conducted by the Louisiana Agricultural Experiment Station designed for the control of the sand wireworm were begun in 1942. Two phases of experimentation were undertaken. One was directed at an immediate method of control through the use of soil poisons and fumigants. The second study was directed at the development of a suitable crop rotation that would starve the wireworms in infested fields. Control by the addition of fumigants to the soil was found to be impractical. Those which showed promise were too costly to consider for use on low income producing soils. Crop rotation, including leaving the land in fallow and pasturage, and the use of large amounts of organic matter proved somewhat successful. However, a long-range complicated crop rotation program does not fit into the economic patten of the cotton-corn farm program practiced in the hill sections of north Louisiana.

With the appearance of the new chlorinated insecticides interest in soil treatment was revived, and in 1947 practical field experiments were set up using several of the new chemicals as soil poisons. Most of these tests, however, were concerned with benzene hexachloride applied at various dosages in the soil at planting time.

1947 EXPERIMENTS.—Three experiments were conducted in 1947, one on each of three different farms located at widely separated points in north Louisiana. However, on two of these farms the wireworm populations were not sufficiently high to obtain differences between the treatments and checks. The infestation was extremely heavy on Farm No. 3 which was located about 10 miles east of Plain Dealing in Bossier parish.

METHOD.—Preliminary tests in 1947 using square rod plots situated side by side were entirely too limited for satisfactory wireworm control studies. Efforts were made to find a field which contained a uniform infestation, and which was large enough to be divided into a randomized plot arrangement. Unfortunately, for experimental purposes, the sand wireworm infestations in the hilly areas are spotty. The infested areas in a field may be only a few feet in diameter or as much as a hundred feet or more. Because of the nature of the infestation, plots for wireworm control studies were selected, when possible, which ran the entire length of the rows. Due to limited areas available for experimentation this type of design was not always possible to obtain.

An experiment located on this farm in Bossier parish consisted of plats about 2.67

square rods in area. The plots followed each other consecutively across the field. This same area a few weeks previously had been planted to corn but the stand was completely destroyed by wireworms. Examination of the corn before complete destruction showed from 2 to 12 wireworms per hill. The land was re-worked and planted as follows: A 6-inch shovel furrow was made. In the bottom of this furrow the insecticide was sprinkled. Next the row was listed, covering the chemicals approximately 8 to 10 inches. A furrow was made about 6 inches deep in which the corn seed was planted. This placed the seed from 2 to 4 inches above the chemicals. Individual plots were 4 rows wide and 30 feet long. Treatments consisted of the row application of 1, 0.5, and 0.25 pound of the gamma isomer of benzene hexachloride per acre. The treatments were replicated twice.

The benzene hexachloride was mixed with the native fine sandy soil in a Day mixing machine. The final mixture contained 1 per cent of the gamma isomer. Treatments and plantings were made on May 12.

RESULTS.—All treated plots were easily distinguished from untreated plots from the time the plants emerged. On June 2, all treated plots contained a perfect stand of corn and the plants averaged 4 inches in height. The stand in the check plots was 50 per cent destroyed by wireworms, and the remaining plants averaged 2 inches in height. There was no sign of any of the treatments causing injury to the plants. The plants in all treated plots appeared normal in every respect. On June 20 the plants in the treated plots averaged 10 inches in height, and by this date the wireworms had destroyed 90 per cent of the stand in the check plots. Soil examination in the check plots showed from 1 to 6 wireworms per hill of corn. No wireworms could be found in any of the treated plots and the corn in all treatments appeared equal in every respect. On July 22, plants in all treated plots averaged approximately 6 feet in height and the stalks were tasseling and forming ears. The few stalks remaining in the check plots averaged only half the size of those in the treated plots.

Harvest records were made on October 2. The entire area of each plot was harvested with the exception of a 30-inch buffer space at both ends of the plots.

Table 1.—Showing effects of several soil treatments on control of the sand wireworm the second season following application (Ringgold, Louisiana). Treatments applied April 14, 1947 by drilling in row by hand. Date of planting was April 5, 1948.

TREATMENT	CONDITION OF PLANTS ON MAY 20, 1948	YIELD PER ACRE
		Bushels
1 lb. gamma isomer BHC per acre	18 to 20 inches high, stand perfect	21
8 oz. gamma isomer BHC per acre	18 to 20 inches high, stand perfect	20
4 oz. gamma isomer BHC per acre	18 to 20 inches high, stand perfect	21
1 lb. DDT (tech.) per acre	6 to 8 inches high, stand about 50% destroyed	11
5 lbs. DDT (tech.) per acre	12 to 18 inches high, stand perfect	17.5
Sulfur, 90 lbs. per acre	Stand 50% destroyed plants about 6 inches high	7.5
5 lbs. chlorinated camphene (tech.) per acre	18 inches high, stand perfect	14.5
Check	Average of 6 inches high, stand 50% destroyed	9

The average yields per acre by treatments are given below:

	Bushels per Acre
16 ounces gamma isomer per acre	26
8 ounces gamma isomer per acre	26
4 ounces gamma isomer per acre	35
Check	2

1948 EXPERIMENTS.—The wireworm control studies in 1948 were conducted on the farms that were used in 1947.

Farm No. 1 (Ringgold, Louisiana).—Two tests were conducted on this farm. Test No. 1 consisted of the planting of corn on the plots treated in the spring of 1947 in order to determine the value of these treatments in the protection of corn from wireworm injury the second crop season after application. These plots were 5 rows wide by 30 feet long and were arranged lengthwise, the rows following the terrace nearest the crest of the field. Each treatment was replicated twice.

The treatments were as follows: Sixteen ounces gamma isomer benzene hexachloride per acre; 8 ounces gamma isomer benzene hexachloride per acre; 4 ounces gamma isomer benzene hexachloride per acre; 1 pound DDT (tech.) per acre; 5 pounds DDT (tech.) per acre; 90 pounds

sulfur per acre; and 5 pounds toxaphene (tech.) per acre. All treatments were applied by hand in the row just previous to the 1947 planting. The wireworm infestation in these plots in 1947 was not sufficiently high to obtain differences between treated and untreated areas.

Test No. 2 consisted of two one-acre plots on land which had been heavily infested with wireworms for several years. Each plot was treated with 8 ounces of the gamma isomer of benzene hexachloride. The material in Plot No. 1 was machine mixed with fine sandy soil whereas in Plot 2 the materials were mixed by hand with a shovel. The application in both cases was made with a one-row fertilizer distributor calibrated to deliver the correct dosage per acre. Each mixture contained 1 per cent of the gamma isomer.

Both tests were planted April 5.

RESULTS.—In Test No. 1 it was evident from the time the plants emerged that most of the materials were effective in protecting the young corn. The plants in the check plots emerged well. Within one month, however, these plots averaged less than a 50 per cent stand, whereas the stand in most of the treated plots was perfect. The wireworm infestation in most of the treated plots was zero. The infestation in the checks ranged from none to as many as 12 wireworms per hill of corn. The plots that had been treated with 1 pound of DDT contained some wireworms though the infestation was not nearly as great as in the checks. The sulfur treated plots were as heavily infested as the checks.

Yield records were made by harvesting the three center rows of each plot. The results are given in table 1.

In Test No. 2 there was no difference between the control secured from the hand-mixed and the machine-mixed materials. Both treatments gave complete protection from wireworms, and each yielded 21 bushels of corn per acre. Untreated areas surrounding these plots were severely infested with wireworms, and produced an average of 9 bushels per acre.

Farm No. 2 (Plain Dealing, Louisiana).—This farm had been heavily infested with wireworms for several years. The areas selected for the 1948 tests were those sections of the field which had consistently been infested for several years.

LARGE-SCALE TESTS.—These plots consisted of 11 or more rows running lengthwise of the field. The area of individual plots averaged slightly less than 0.5 acre. Treatments were as follows: (1) 4 ounces gamma isomer benzene hexachloride per acre; (2) 16 ounces gamma isomer benzene hexachloride per acre; (3) 25 pounds DDT (tech.) per acre. (The three treatments above were pre-mixed with fine sandy soil); (4) One pound gamma isomer benzene hexachloride per acre, and (5) 2.5 pounds chlordane (tech.) per acre. (The last two named treatments were premixed with 6-8-8 fertilizer). All materials were applied with a one-row fertilizer distributor. The fertilizer was applied at the rate of 300 pounds per acre.

RESULTS.—All treatments appeared to give complete control of the wireworms. Soil examinations showed considerable numbers of wireworms in the check plots. The infestation ranged from none up to as many as 12 per hill. No wireworms were found in any of the treated plots, and the plants appeared healthy and normal. The plants in the check plots showed severe damage to both the stand and the condition. One month after planting, the checks contained a 50 per cent stand, and these stalks were severely stunted. Actual yield records were not secured from any of these large plots. The estimated yield from treated plots was 25 bushels per acre, and 6 bushels on the checks.

SMALL-PLOT TEST.—A heavily infested one-acre plot of ground on this same farm was selected for this test. This acre was divided into four plots of equal size which were treated on October 21, 1947, by broadcasting soil-benzene hexachloride mixtures by hand, and following immediately with a disk harrow which tended to cover and somewhat incorporate the material in the soil. Treatments used were as follows: (1) One pound gamma isomer of benzene hexachloride per acre; (2) 8 ounces gamma isomer of benzene hexachloride per acre; (3) 2 ounces gamma isomer of benzene hexachloride per acre, and (4) check.

These plots remained in fallow until the following spring when they were fertilized with a 6-8-8 fertilizer at the rate of 400 pounds per acre at the time the land was prepared for planting. The plots were planted to Dixie 11 hybrid corn on April

Table 2.—Showing effects of several dosages of benzene hexachloride on wireworms when applied the fall previous to planting (Plain Dealing, Louisiana). Treatments applied October 21, 1947 and planting of plots was on April 15, 1948.

TREATMENT	METHOD OF APPLICATION	CONDITION OF PLANTS ON MAY 18	YIELD PER ACRE
			Bushels
One pound gamma isomer benzene hexachloride per acre	Broadcast by hand—covered with disk harrow	18 inches high—green color—vigorous	32
8 ounces gamma isomer benzene hexachloride per acre	Broadcast by hand—covered with disk harrow	18 inches high—green color—vigorous	41
2 ounces gamma isomer benzene hexachloride per acre	Broadcast by hand—covered with disk harrow	18 inches high—green color—vigorous	40
Check	—	6 inches high—worm population high—50% of plants totally destroyed	12

15. The rows were 6 feet apart, and the plants were spaced 18 inches in the row. Results of this test are shown in Table 2.

SUMMARY.—Tests conducted in 1947 using benzene hexachloride in the soil at the rates of 4, 8, and 16 ounces of the gamma isomer per acre in row treatments gave complete protection of the corn plants from injury by the sand wireworm. Untreated corn adjacent to treated areas was severely affected, often to the extent of total destruction of the plants. Yields on treated plots ranged from 26 to 35 bushels per acre. Check plots produced an average of 2 bushels per acre.

Corn grown in 1948 on plots treated in the spring of 1947 with the above dosages of benzene hexachloride without any additional treatments showed that benzene hexachloride is effective the second crop season following application. Treated plots were free of wireworms throughout the season and produced an average of 21 bushels of corn per acre. Untreated plots were heavily infested with wireworms and produced an average of 9 bushels per acre. Five pounds technical DDT per acre, and 5 pounds technical toxaphene per acre also gave promising results in the same test.

Large plots were treated in 1948 with dosages of benzene hexachloride ranging from 4 ounces to 1 pound of the gamma isomer per acre mixed with sandy soil and with a complete fertilizer. Chlordane (2.5 pounds technical per acre) and DDT (25 pounds technical per acre) were also tested. The condition of the plants in these plots together with soil examinations showed that all the materials used were highly effective in the control of the sand wireworm. Apparently neither the fertilizer nor the insecticides was affected by the presence of the other when they were mixed together before application.

Plots treated by hand broadcasting the fall before planting showed the complete effectiveness of benzene hexachloride in dosages as low as 2 ounces of the gamma isomer per acre in the protection of corn from attack by the wireworm the following spring. Yields from treated plots averaged 38 bushels of corn per acre, whereas the average yield from the untreated area was 12 bushels per acre.

DR. R. D. GLASGOW RETIRES

Dr. Robert D. Glasgow, state entomologist of New York has retired, after many years of service. Before coming to New York he was on the staff of the University of Illinois for 15 years.

Destruction of Certain Insect Predators by Applications of Insecticides to Control Cotton Pests

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During 1947 when the new chlorinated compounds came into general use for the control of cotton pests, the occurrence of some unusual insect outbreaks suggested that such materials might be seriously detrimental to the natural enemies of these pests.

In some fields which had been dusted with a mixture of benzene hexachloride and DDT (3 per cent gamma isomer benzene hexachloride and 5 per cent DDT) for control of the cotton fleahopper, *Psallus seriatus* (Reut.), damaging infestations of second generation bollworm, *Heliothis armigera* (Hbn.), developed. Ordinarily this generation does not damage cotton in Louisiana. Severe bollworm infestation developed in one area where approximately 10,000 acres received three to five applications of either a 20 per cent toxaphene dust or the benzene hexachloride-DDT mixture for boll weevil control. No bollworm damage occurred in a few small fields scattered about this area where no insecticide had been applied.

Injurious bollworm infestations developed from comparatively small numbers of eggs in some fields which had been treated with the chlorinated materials. In similar fields which were not dusted no injury was observed. Heavy infestations of the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, occurred in many fields where the new organic insecticides had been used.

The consistency with which such infestations were associated with applications of the new organic insecticides suggested that these materials were interfering with natural control normally effected by insect enemies of these pests. Workers with other crops have reported the use of chlorinated compounds to interfere with the natural balance existing between plant pests and their natural enemies (Hough 1946; Newcomer *et al.* 1946; Michelbacher *et al.* 1946; and Rings & Weaver 1948).

The importance of natural enemies in the control of cotton pests has not been well studied. In some areas it is recognized that damage from the cotton aphid, *Aphis gossypii* Glover, may offset gains from boll weevil control with calcium arsenate unless an aphicide is included (Gaines 1942). Aphid damage to cotton following applications of calcium arsenate apparently results from destruction of the insect enemies which normally control this pest (Isely 1946).

Bishopp (1929), Fletcher (1929), Sherman (1930), and Ewing & Ivy (1943) have called attention to the fact that populations of the bollworm and damage by this insect may be greater in plots of cotton dusted with arsenicals for boll weevil control, or improperly dusted for bollworm control, than in similar undusted plots. The latter reported that in Texas during 1941 increased damage from the bollworm frequently offset gains from earlier dusting for boll weevil control. They suggested that the increase in bollworm populations following the use of arsenicals could be caused by the increase in aphid populations which usually follows and affects the host relationships of the predators that normally live on aphids and the eggs and young larvae of the bollworm.

As predators of bollworm eggs in Texas, Ewing & Ivy (1943) list *Chrysopa rufilabris* Burm., *Hippodamia convergens* Guer., *Coleomegilla fuscilabris* (Muls.), *Collops balteatus* Lec., *Podisus maculiventris* (Say), *Zelus socius* Uhl., *Z. renardii* Kol., *Orius insidiosus* (Say), *Geocoris punctipes* (Say), *Scymnus creperus* Muls., and *Melanophthalma distinguenda* (Com). Barber (1936) reported that *O. insidiosus* was the most important insect enemy of the corn ear worm in central Virginia, where it destroyed an average of 38.47 per cent of the eggs deposited on corn plants. It was also found to feed readily on small larvae.

McGregor (1917), in a study of the red spider mite on cotton, found *Scolothrips sexmaculatus* (Perg.), *Orius insidiosus*, *Geocoris punctipes*, and species of Chrysopidae, Syrphidae, and Coccinellidae to be important natural enemies of this pest.

[1] T. R. Pfrimmer and D. F. Clower gave valuable assistance in these studies.

During 1948, in connection with field tests for the control of the boll weevil, data were collected on the effect of some of the more commonly used cotton insecticides upon the populations of those species reported as predators which are frequently found in cotton fields in Louisiana. Included in the study were six species of *Coccinellidae*,[1] *Orius insidiosus*, and *Geocoris punctipes*.[2]

EXPERIMENTAL PROCEDURE.—Since these tests were designed for control of the boll weevil, insecticide applications were made in the late afternoon at intervals of four to five days. Beneficial insect populations were recorded by counting the number of specimens collected in 50 sweeps per plot in the small plot tests and 100 sweeps per plot in the large plot test with a sweeping net 12 inches in diameter. These records were usually made during the morning or early afternoon of the day an insecticide application was scheduled to be made.

Experiment 1 consisted of six treatments and an untreated check replicated four times in randomized blocks. Plots were 16 rows wide and of sufficient length to make one-tenth acre. Materials were applied with rotary hand dusters.

Experiment 2 consisted of eight treatments and an untreated check replicated six times in randomized blocks. In other respects it was similar to experiment 1.

Experiment 3 consisted of four treatments and an untreated check replicated four times in randomized blocks. Plots were 24 rows wide and of sufficient length to average approximately two acres in size. Materials were applied with a six-row tractor-mounted power duster.

Table 1.—The effect of three insecticides in two schedules of application upon the populations of some beneficial insects. Average of five records. Experiment 1, Caspiana, Louisiana, 1948.

TREATMENT	INSECTICIDE PER ACRE PER APPLICATION	AVERAGE PER 100 SWEEPS		
		Coccinellidae	*Geocoris punctipes*	*Orius insidiosus*
(1) Calcium arsenate in alternate application with calcium arsenate containing 2% nicotine—2 applications beginning July 20	10.9 lbs.	8.9	2.8[1]	9.8
(2) Toxaphene 20% plus sulfur 40%—2 applications beginning July 20	11.4 lbs.	6.1	3.8	7.7[1]
(3) Benzene hexachloride-DDT-S (3% gamma isomer benzene hexachloride, 5% DDT, and 40% sulfur) 6 applications beginning June 23	9.7 lbs.	4.3[1]	1.6[2]	8.8[1]
(4) Same as number 3—two applications beginning July 20	10.9 lbs.	6.7	2.7[1]	11.6
(5) Same as number 1—six applications beginning June 23	10.1 lbs.	3.1[1]	3.9	7.2[1]
(6) Same as number 2—six applications beginning June 23	10.6 lbs.	3.8[1]	0.3[2]	3.6[2]
(7) Check	—	9.8	5.1	12.3
Difference required for significance 5% level	—	4.50	1.99	2.82

[1] Showing significant decrease at 5% level below untreated check.
[2] Showing significant decrease at 5% level below calcium arsenate-nicotine.

RESULTS AND DISCUSSION.—Results from these tests are summarized in tables 1, 2, 3 and 4.

These data consistently show the new organic compounds to have a more detrimental effect than calcium arsenate-nicotine on the populations of *Geocoris punctipes* and *Orius insidiosus*. Such was not the case with the Coccinellidae as cal-

[1] *Coleomegilla maculata* (Deg.), *Hippodamia convergens* (Chev.), *Cycloneda sanguinea* (L.), *C. munda* (Say), *Scymnus creperus* (Muls.), and *S. loewii* (Muls.)

[2] Insect identifications by the Division of Insect Identifications, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

Table 2.—The effect of several insecticides upon the populations of some beneficial insects. Average of seven records. Benton, Louisiana, 1948.

Treatment	Insecticide per Acre per Application	Average Predators per 100 Sweeps		
		Coccinellidae	*Geocoris punctipes*	*Orius insidiosus*
(1) Benzene hexachloride-DDT-S (3% gamma isomer benzene hexachloride, 5% DDT, and 40% sulfur[3]	10.2 lbs.	1.7[1]	2.0	4.2[1]
(2) Special calcium arsenate containing 2% gamma isomer benzene hexachloride	9.8 lbs.	1.7[1]	1.0[2]	4.7[1]
(3) Calcium arsenate containing 0.2% rotenone and 0.8% piperonyl cyclonene	9.7 lbs.	2.5[1]	3.1	5.8[1]
(4) Benzene hexachloride-DDT-S (3% gamma isomer benzene hexachloride, 5% DDT and 40% sulfur) in alternate application with calcium arsenate	9.7 lbs.	1.7[1]	1.8	4.5[1]
(5) Chlordane 3% plus DDT 3%	10.5 lbs.	3.3	2.2	5.5[1]
(6) Toxaphene 20% plus sulfur 40%	11.1 lbs.	2.3[1]	0.8[2]	2.9[2]
(7) Calcium arsenate in alternate application with calcium arsenate containing 2% nicotine	11.2 lbs.	1.5[1]	2.4	5.1[1]
(8) Check	—	4.1	2.7	8.0
(9) Chlordane 10%	9.8 lbs.	4.7	1.1[2]	4.0[1]
Difference required for significance 5% level	—	1.4	1.3	1.7

[1] Showing significant decrease at 5% level below untreated check.
[2] Showing significant decrease at 5% level below calcium arsenate-nicotine.
[3] Eight applications of all materials were made beginning July 7.

Table 3.—The effect of two insecticides in two schedules of application upon the populations of some beneficial insects. Average of five records. Experiment 3, Benton, Louisiana, 1948.

Treatment	Average Amount Insecticide per Acre per Application	Average Predators per 100 Sweeps		
		Coccinellidae	*Geocoris punctipes*	*Orius insidiosus*
(1) Check	—	4.0	5.4	9.4
(2) Benzene hexachloride-DDT-S (3% gamma isomer benzene hexachloride, 5% DDT, and 40% sulfur) 5 applications beginning July 19	7.4 lbs.	0.8[1]	1.1[2]	2.2[2]
(3) Same as number 2—three applications beginning August 2	6.9 lbs.	3.1	3.2[1]	7.2[1]
(4) Calcium arsenatein alternate application with calcium arsenate containing 2% nicotine—three applications beginning August 2	6.9 lbs.	3.8	3.1[1]	7.1[1]
(5) Same as number 4—five applications beginning July 19	6.2 lbs.	1.0[1]	3.8	5.7[1]
Difference required for significance 5% eve	—	1.20	1.98	1.85

[1] Showing significant decrease at 5% level below untreated check.
[2] Showing significant decrease at 5% level below calcium arsenate-nicotine.

cium arsenate-nicotine was fully as destructive to this group as the chlorinated materials. Toxaphene was more destructive to the species studied than any other material included in the tests. It signifi-

Table 4.—Comparison of bollworm damage in Experiments 2 and 3.

Treatments	Per Cent Squares Punctured by Bollworm. Average of 6 Records for Each Experiment from July 22 to August 14	
	Experiment 2	Experiment 3
Calcium arsenate in alternate applications with calcium arsenate containing 2 per cent nicotine	9.0	2.4
Benzene hexachloride-DDT-Sulfur	7.1	1.9
Check	10.5	2.6

cantly reduced their numbers, except the Coccinellidae, below that in the calcium arsenate-nicotine treated plots. The benzene hexachloride-DDT-sulphur mixture significantly reduced the population of *G. punctipes* and *O. insidiosus* in experiment No. 3 and *G. punctipes* in experiments 1 and 2 below that in the calcium arsenate-nicotine plots. Chlordan significantly reduced the number of *G. punctipes* below that in the calcium arsenate-nicotine plots. All materials reduced populations below those in the untreated checks.

Results from experiments 2 and 3 suggest that time of beginning applications of insecticides may have an important effect on the balance existing between beneficial insects and their hosts. These experiments were located in a field which had been uniformly treated as to time of planting, fertilization, and cultivation. They were separated by 12 untreated rows. The two tests differed in time of beginning treatments, number of applications, and method of application. In experiment 2, eight applications, beginning July 7, were applied with rotary hand dusters. In experiment 3, five applications, beginning July 19, were applied with a power duster.

A damaging bollworm infestation developed in experiment 2, but it failed to develop to injurious proportions in experiment 3. A comparison of two materials and the untreated checks which were included in both experiments is given in table 4.

These data are too preliminary in nature to justify the drawing of conclusions. It is also recognized that in experiments such as these populations of beneficial insects are dependent upon a complexity of factors which would require careful study before the effects of an insecticide upon a given species could be properly evaluated. With these limitations in mind, however, results from these tests indicate that the chlorinated materials which are being generally recommended as cotton insecticides may be expected to seriously affect the balance which normally exists in untreated fields between such pests as the cotton aphid, spider mites, and the bollworm and their natural enemies.

SUMMARY.—The effect of some commonly used cotton insecticides upon populations of predators of the cotton aphid, bollworm, and spider mites was studied in field plot tests in 1948. All insecticides studied reduced the populations of these beneficial species. The new organic insecticides were more detrimental to two predators, *Geocoris punctipes* and *Orius insidiosus*, than was calcium arsenate-nicotine.

LITERATURE CITED

Barber, G. W. 1936. *Orius insidiosus* (Say), an important natural enemy of the corn ear worm. U.S.D.A. Tech. Bul. **504.**

Bishopp, F. C. 1929. The bollworm or corn ear worm as a cotton pest. U.S.D.A. Farmer's Bul. **1595.**

Ewing, K. P., and E. E. Evy. 1943. Some factors influencing bollworm populations and damage. JOUR. ECON. ENT. **36:** 602–6.

Fletcher, Robert K. 1929. The uneven distribution of *Heliothis obsoleta* (Fabricius) on cotton in Texas. JOUR. ECON. ENT. **22:** 757–60.

Gaines, R. C. 1942. Effect of boll weevil control and cotton aphid control on yield. JOUR. ECON. ENT. **35:** 493–5

Hough, W. S. 1946. The control of mites on apple trees sprayed with DDT. JOUR. ECON. ENT. **39:** 266–7.

Isely, Dwight. 1946. The cotton aphid. Ark. Agr. Expt. Sta. Bul. **462.**

McGregor, E. A., and F. L. McDonough. 1917. The red spider on cotton. U.S.D.A. Bul. **416.**

Michelbacher, A. E., Clark Swanson, and W. W. Middledauff. 1946. Increase in the population of *Lecanium pruinosum* on English walnuts following applications of DDT sprays. JOUR. ECON. ENT. **39:** 812–13.

Newcomer, E. J., F. P. Dean, and F. W. Carlson. 1946. Effect of DDT, xanthone, and nicotine bentonite on the wooly apple aphid. JOUR. ECON. ENT. **39:** 674–6.

Rings, Roy W., and C. W. Weaver. 1948. Effects of benzene hexachloride and DDT upon parasitization of the oriental fruit moth. JOUR. ECON. ENT. **41:** 566–9.

Sherman, Franklin. 1930. Results of airplane dusting in the control of cotton bollworm (*Heliothis obsoleta* Fab.). JOUR. ECON. ENT. **23:** 810–3.

Control of the Southern Corn Rootworm and the Seed-Corn Maggot in Louisiana

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Experiments were begun in 1948 by the Louisiana Agricultural Experiment Station in an effort to determine the extent of damage done to corn by the southern corn rootworm, *Diabrotica duodecimpunctata* (F.), and the seedcorn maggot, *Hylemyia cilicrura* Rond., and to discover, if possible, a practical means of controlling these two species.

Both species have been known to attack seedling corn; however, the actual amount of damage done by each had not been accurately evaluated. Certain circumstances, such as a late and wet spring, or planting too early following the plowing under of a green manure crop, were known to influence the severity of attack by these two insects.

An experiment was designed whereby several materials were tested for controlling these insects by adding them to the soil or to the fertilizer before planting time. The field under study was approximately 2 acres in area, and was divided into 12 equal size plots of 8 rows each. Each plot ran the entire length of the field. A heavy crop of vetch and winter peas was grown on this field during the winter of 1947–48 and was plowed under on March 17—6 days before planting.

The chemicals used were mixed with the fertilizer in such a concentration as to provide the desired dosage when the fertilizer was used at the rate of 300 pounds per acre.

The corn planted was Louisiana hybrid 521. The seeds were spaced approximately 4 inches apart, but the stand was thinned later to an average of one stalk per row-foot. This close planting gave three times the desired stand thus permitting the removal of plants without affecting the final stand. The corn was planted on March 23—the same date the fertilizer and chemicals were applied to the soil. Application of the fertilizer-chemical mixtures was made with a one-row fertilizer distributor.

Treatments were as follows: One pound of the gamma isomer of benzene hexachloride per acre (pre-mixed in 4-12-4 fertilizer); (2) 5 pounds chlordan (technical) per acre (pre-mixed in 4-12-4 fertilizer); (3) 25 pounds DDT (technical) per acre (pre-mixed in 4-12-4 fertilizer); (4) fertilizer alone; (5) tung nut hull meal alone—30 pounds per acre; and (6) check (nothing).

Table 1.—Showing effectiveness of several materials in the control of the southern corn rootworm on corn.

TREATMENT	AVERAGE NO. PLANTS THAT EMERGED PER ROW	PER CENT OF PLANTS DESTROYED BY CORN ROOTWORM 16 DAYS AFTER PLANTING	PER CENT OF PLANTS DESTROYED BY CORN ROOTWORM 24 DAYS AFTER PLANTING
Benzene Hexachloride[1] and Fertilizers	808	1.0%	2.4%
Chordane[2] and Fertilizer	850	3.8%	5.6%
Fertilizer alone	667	15.7%	31.5%
DDT[3] and Fertilizer	796	13.8%	21.6%
Tung Nut Hull Meal alone (30 pounds per acre)	737	12.1%	29.3%
Check (nothing)	661	17.2%	33.1%

[1] One pound gamma isomer per acre.
[2] Five pounds (technical) per acre.
[3] Twenty-five pounds (technical) per acre.

RESULTS.—Observations and records were made from the time the young plants emerged until harvest. Table 1 gives the stand count and the effect of the treatments on the corn rootworm 16 and 24 days after planting. Table 2 shows the

degree of injury by the seed corn maggot with the apparent effect on stalk development 21 days after planting. Yield records are also given in table 2. Plants in plots treated with chlordane, benzene hexachloride and DDT grew faster and larger than plants in the other treatments. This difference in growth and development was evident from the time the plants were 2 or 3 inches in height until they were approximately 2 to 3 feet high. At this time the plants in the various treatments became more uniform in development.

Injury by the corn rootworm was characterized by a transverse hole made by the larva just below the soil level. This hole often traversed the entire stalk, cutting the center bud or heart of the plant which wilted and died, leaving the basal leaves unaffected. These affected plants often continued to live and sucker at the ground level, but produced no grain.

Seed-corn maggot injury to the plant was characterized by an area eaten out of the hypocotyl—often to the extent of severing the seed from the upper portions of the plant. This injury to the hypocotyl

Table 2.—Showing effectiveness of several materials in the control of the seed-corn maggot on corn.

Treatment	Plants[1] Injured by Seed-Corn Maggot	Average Length[1] of Stalk	Average Weight[1] per Plant	Yield —per Acre
				Bushels
Benzene Hexachloride and Fertilizer	30%	38.8 cm.	8.0 gms.	75
Chlordane and Fertilizer	20%	39.0 cm.	8.2 gms.	77
Fertilizer alone	93%	34.9 cm.	6.9 gms.	58
DDT and Fertilizer	50%	36.6 cm.	8.2 gms.	77
Tung Nut Hull Meal alone	58%	29.0 cm.	4.4 gms.	53
Check (nothing)	85%	29.8 cm.	4.9 gms.	49

[1] Records made 20 days after planting.

no doubt interfered with the translocation of food, resulting in a general weakening and dwarfing of the plants. Following the development of the secondary root system, plants injured by maggots tended to outgrow the dwarfed condition.

At one time during the course of the experiment, some of the plants in one of the benzene hexachloride plots showed severe phosphate deficiency symptoms. The plants at this time were approximately 18 inches high. Soil analysis showed that soluble phosphorus was abundant in the soil. Plant tissue analysis indicated the scarcity of phosphorus in affected plants.

DISCUSSION.—A study of table 1 shows the effectiveness of benzene hexachloride and chlordane in the control of the southern corn rootworm. DDT, fertilizer alone, and tung nut hull meal gave but little, if any, control of this species. It is also interesting to note that chlordane and benzene hexachloride gave protection against rootworm damage until the plants were safe from attack by them. The figures in column 1 of table 1 showing the original number of plants that emerged per row, in all probability reflect the influence of the seed-corn maggot on the germinating seed. Examination of the seed in the soil showed that a high percentage of them had been destroyed by the seed-corn maggot.

Table 2 shows the effectiveness of chlordane and benzene hexachloride in the control of the seed-corn maggot. Neither DDT nor tung nut hull meal was as effective as chlordane or benzene hexachloride. Fifty per cent of the plants in the DDT plots showed injury caused by the seed-corn maggot. The extent of injury in individual plants was usually not as severe as in untreated plots. However, this treatment gave yields equal to the chlordane and benzene hexachloride treatments. There appears a possibility that, even with this limited protection, the plants were able to utilize efficiently the available fertilizer. It is also of interest to note that the yields from all three treatments were equal, even though the corn rootworm was almost perfectly controlled in the chlordane and benzene hexachloride plots but was only partially controlled in the DDT plots. This indicated that a corn rootworm infestation comparable to the one in this experiment—and it would be considered a fairly heavy infestation in Louisiana—does not materially influence yield unless the stand is reduced below the minimum necessary for maximum production. It is the opinion of the writers that the main damage done by the corn rootworm to corn is in the reduction of stand in the seedling stage which in cases of severe infestations would necessitate re-planting.

The application at planting time of 300 pounds per acre of 4-12-4 fertilizer gave an increase of 9 bushels of corn over unfertilized plots. When this same rate of fertilization was used along with 1 pound

of the gamma isomer of benzene hexachloride, or 5 pounds of chlordane, or 25 pounds of DDT per acre the yield of corn was increased approximately 28 bushels per acre over unfertilized and untreated plots, or an average increase of approximately 18 bushels corn per acre from the use of the insecticidal chemicals along with the fertilizer. Nitrogen was applied as a side dressing at the rate of 25 pounds per acre to all plots.

Later in the season, after the maggots and rootworms had emerged from the soil, nutritional tests were conducted using chlordane, benzene hexachloride, and DDT at various dosages in the soil. In no case did any of the materials show any value as a plant nutrient to corn. Also none of the materials, so far as could be determined, visibly affected germination or produced any abnormal condition of the plants after emergence. One possible exception to this was where some plants in one benzene hexachloride plot exhibited phosphorus deficiency symptoms. However, benzene hexachloride used in pots in the greenhouse in dosages as low as 4 ounces gamma isomer per acre produced corn seedlings that, soon after emerging, began to grow downward, with the terminal bud in some cases coming in contact with the soil line. All plants thus affected ultimately died. No such condition, however, has ever been observed in the field.

A standard practice among farmers is to wait 3 weeks or more before planting seed after a cover crop has been turned under. The reason for this delay is to permit decomposition of the organic matter before the seed is planted. The process of decomposition resulting in reduced available nitrogen in the soil is said to interfere with germination, and seriously to retard growth and development of the young plant. Regardless of the theories, it is a fact that corn cannot be successfully planted immediately following turning under a green manure crop. It is the opinion of the writers that at least a portion of these unfavorable results is due to the damage done by the seed-corn maggot rather than to a decomposition-nitrogen relationship.

SUMMARY.—DDT Benzene hexachloride, chlordane, and tung nut hull meal were tested in an experiment designed for the study of the southern corn root worm and the seed-corn maggot on corn. Chlordane and benzene hexachloride were highly effective in reducing injury by both species. DDT also gave fair control of the seed-corn maggot. Yields from all three treatments averaged 18 bushels more corn per acre than from plots where only fertilizer was applied. Fertilizer alone resulted in an increase of 9 bushels per acre over unfertilized check plots. Injury by the seed-corn maggot to corn was characterized by a general yellowing and stunting of the plant which lasted until the plant had developed its secondary root system. Rootworm damage was characterized by a hole bored through the young plant just below the soil line. This hole cut the heart or bud of the seedling, thus causing a dead heart in attacked plants. Often the basal leaves were left unaffected, and the plant would continue to live but tend to branch or sucker from the ground.

So far as could be determined, neither chlordane nor DDT offered any nutritional value to corn, neither did either of them cause any injury to the plants. Some plants in one of the benzene hexachloride plots appeared to suffer from phosphorus deficiency in the presence of abundant soluble phosphorus in the soil. The reason for this condition was not determined.

DR. BRUES IN THE PHILIPPINES

Dr. Charles T. Brues and Mrs. Brues are spending nine months in the Philippines, at Silliman University in Dumaguete on the island of Negros, some 600 miles south of Manila, where they are doing entomological and other biological work under grants by the Fulbright Programs Branch of the United States Department of State. This is in cooperation with the International Educational Foundation. They are working mainly in cooperation with Dr. James W. Chapman, a student of ants, who has been professor of zoology at Silliman for many years. Doctor Brues expects to continue his work on the fauna of thermal springs and on fluorescent plant materials as biological stains. Mrs. Brues will take motion pictures of insects and other animals and plant life, in which she has become expert. Together they hope, also, to add to the knowledge of the fauna of the region.

Control of the Orange Tortrix on Red Raspberries[1]

CARL JOHANSEN[2] and E. P. BREAKEY[3]

The following tests and observations on the control of the orange tortrix, *Argyrotaenia citrana* Fern., on red raspberries in the Puyallup Valley were made in 1948. This is a continuation of the work begun in 1947.[4]

Materials[5]

1. Cryolite, 90 per cent sodium fluoaluminate.
2. Dichlorodiphenyl dichloroethane, 50 per cent wettable spray powder.
3. Ditolyl trichloroethane, 50 per cent wettable spray powder.
4. Methoxychlor, 50 per cent wettable spray powder.
5. Chlordane, 44 per cent spray concentrate.
6. Tetraethyl pyrophosphate, spray concentrate containing 10 per cent tetraethyl pyrophosphate and 15 per cent other ethyl phosphates in an emulsible base.
7. Parathion, 25 per cent wettable spray powder.
8. Dusting sulfur, 42 per cent sulfur fused with bentonite.
9. Methylated naphthalenes
   Summer oil emulsion
10. Dust deposit builder
    An aluminum magnesium silicate diluent for dusts.[5] (attapulgite)
11. Pyrophyllite, anhydrous aluminum silicate diluent for dusts. Used in these studies unless otherwise indicated.

TEST NO. 1.—*Methods.*—Test plots were laid out in a planting of Tahoma raspberries in North Puyallup. The average population of orange tortrix larvae before spraying was 14 per 100 hills. Each treatment was replicated four times, and each replicate consisted of one-half row (about 65 feet) protected by a buffer row on each side. Applications were made on April 16 and 30, May 17, and June 2. Counts were made about a week after each application and five counts were taken after the last application. The cryolite spray contained 2 lbs. of 90 per cent cryolite per 100 gallons, plus 1 quart summer oil emulsion; the cryolite dust was mixed to contain 50 per cent cryolite, 10 per cent attapulgite, and 3 per cent methylated naphthalenes; the dichlorodiphenyl dichloroethane spray contained 2 lbs. of 50 per cent wettable powder per 100 gallons; the dichlorodiphenyl dichloroethane dust contained 5 per cent of the active ingredient, 10 per cent attapulgite and 3 per cent methylated naphthalenes; the methoxychlor spray contained 2 lbs. of 50 per cent wettable powder per 100 gallons; and the parathion spray contained 0.3 lb. 25 per cent wettable powder per 100 gallons. All sprays were applied with a 50-gallon power sprayer with 2 booms, 4 nozzles per boom. The dusts were applied with a rotary-type hand duster. Each spray was applied at an average of 200 gallons per acre, and each dust at an average of 30 lbs. per acre.

Results.—The results obtained from this test are given in table 1. These results are largely self-explanatory.

It should be noted, however, that dichlorodiphenyl dichloroethane had a better residual action than any of the other materials tested.

TEST NO. 2.—*Methods.*—Plots were also laid out in a planting of Washington raspberries on Clark's Creek Road just south of Puyallup. The average population of orange tortrix larvae before spraying was 6 per 100 hills. Each treatment was replicated 8 times, and each replicate consisted of one-half row (about 70 feet) protected by a buffer row on each side.

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[4] JOURNAL OF ECONOMIC ENTOMOLOGY, 41: 805–806, 1948.

[5] 1. *Kryocide*, natural cryolite, Pennsylvania Salt Co.; *Alorco*, synthetic cryolite, Aluminum Co. of America. 2. *Rhothane*, DDD, Rohm & Haas Co. 3. *Gy-tol*, ditolyl trichloroethane, Geigy Co. 4. *Marlate*, duPont Co. 5. *Zerodane*, U. S. Insecticide Co.; *Colorado 44*, Chemical Corp. of Colorado. 6. *Lathex*, Vis-Ko, Inc. 7. *Thiophos 3422*, American Cyanamid Co. 8. *Koladust*, Niagara Chemical Div. 9. *AR-60*, Velsicol Corp. 10. *Medol*. Shell Oil Co. 11. *CP-5*, Colloidal Products Co. 12. *Attaclay*, Attapulgus Co. 13. *Pyrax ABB*, R. D. Vanderbilt Co.

Table 1.—Control of the orange tortrix on raspberries, Kallgren's Place, 1948.

Materials	Number of Living Larvae Per 40 Hills							
	4/22	5/6	5/25	6/24	7/6	7/14	7/27	8/16	Total
Cryolite Spray	4	2	0	1	0	0	1	11	19
Cryolite Dust	4	1	0	0	0	0	0	7	12
Dichlorodiphenyl dichloroethane Spray	1	0	0	0	0	0	0	1	2[1]
Dichlorodiphenyl dichloroethane Dust	0	0	0	0	0	0	1	1	2[1]
Methoxychlor Spray	3	0	0	0	0	0	1	11	15
Parathion Spray	0	0	0	0	0	1	1	9	11

[1] Figures highly significant as compared to cryolite spray.

The sprays were applied on April 20, May 4 and 22, and June 11. Counts were made about a week after each application and four counts were taken after the last application. The cryolite spray contained 2 lbs. per 100 gallons; the dichlorodiphenyl dichloroethane spray contained 2 lbs. 50 per cent wettable powder per 100 gallons; the ditolyl trichloroethane spray contained 2 lbs. 50 per cent wettable powder per 100 gallons; the chlordan spray contained 1 qt. 44 per cent emulsion per 100 gallons; the tetraethyl pyrophosphate spray contained 1 pt. of the spray concentrate per 100 gallons; and the parathion spray contained 0.3 lb. 25 per cent wettable powder per 100 gallons. These sprays were applied with a 100-gallon power sprayer and two berry guns at the rate of 200 gallons per acre.

RESULTS.—The results obtained from this test are given in table 2.

It will be noted that the dichlorodiphenyl dichloroethane again had the best residual action and gave highly significant results as compared to those obtained with cryolite.

TEST NO. 3.—*Methods.*—Eight plots of Washington raspberries, ranging in size from 0.25 to 1 acre were used to test the effectiveness of insecticide dusts. Large plots were used in place of the usual smaller randomized plots, because of the hazard due to dust drift. The plots were located in fields belonging to four different growers: A, B, C, D, table 3. The dusts were applied April 30, May 21, and June 3. Counts were made about a week after each application, and two counts were taken after the last application. Three additional counts were made in two of the treatments which were given an extra dusting with the methoxychlor during the picking season because of poor residual action. The cryolite 61 dust contained 61 per cent natural cryolite, 10 per cent attapulgite and 3 per cent methylated naphthalenes; the sulfur and cryolite 50–50 dust contained 50 per cent natural cryolite and 50 per cent dusting sulfur; the cryolite 50 dust (A, 3) contained 50 per cent synthetic cryolite and 8 per cent deposit builder; the methoxychlor 5 dust contained 5 per cent methoxychlor; the cryolite 50 dust (B) contained 50 per cent nat-

Table 2.—Control of the orange tortrix on raspberries, G. Richter's Place, 1948.

Materials	Number of Living Larvae per 40 Hills							
	5/1	5/11	6/1	6/24	7/14	7/27	8/16	Totals
Cryolite Spray	0	0	0	1	4	3	9	17
Dichlorodiphenyl dichloroethane Spray	1	0	0	0	1	0	1	3
Ditolyl trichloroethane Spray	2	0	0	0	4	6	8	20
Chlordane Spray	0			omitted (phytotoxicity)				
Tetraethyl pyrophosphate Spray	4			omitted (poor control)				
Parathion Spray	0	0	0	1	0	7	12	20

ural cryolite, 10 per cent attapulgite and 3 per cent methylated naphthalenes; the cryolite 50 dust (C) contained 50 per cent synthetic cryolite; the cryolite 70 dust (D) contained 70 per cent natural cryolite; and the dichlorodiphenyl dichloroethane 5 dust contained 5 per cent of the active ingredient.

All of these dusts, except the last two tabulated, were applied with a power duster equipped with 4 fish-tail nozzles and mounted on a tractor. The last two were applied with a rotary-type hand duster. These dusts fed out of the dusters at varying rates, ranging from 21 lbs. per acre (sulfur and deposit builder mixes) to 34 lbs. per acre (synthetic cryolite 50 per cent mix).

RESULTS.—The results obtained from the use of these dusts are given in tables 3 and 4.

It will be noted by referring to table 3 that the methoxychlor 5 had very poor residual action. However, applications of this same material during the picking season reduced the infestation at that time. The use of a number of different cryolite dusts, varying in strength, diluents, and whether formed with the synthetic or natural material, failed to bring out much variation in the final results. The variation in results from the four plots of field A may be due to differences in pre-dust population and position in the field. The dichlorodiphenyl dichloroethane 5 used on the plots of field D gave highly significant results as compared to the cryolite 70 in the same field.

PHYTOTOXICITY.—During the course of these experiments, the insecticides tested for the control of the orange tortrix produced several types of foliage injury. In each instance, efforts were made to identify the symptoms with the cause of the injury, and to correct or compensate for this undesirable effect.

The application of excessive strengths of dichlorodiphenyl dichloroethane to red raspberries, as either a spray or a dust, or as a spray with an oil sticker, caused a yellow chlorotic blotching of the leaves. It also caused a malformation and stunting of young foliage. The problem was eliminated by using this material at a maximum of 2 lbs. per 100 gallons of water (1 lb. per 100 gal. has given good control of the insect in question), and omitting the oil sticker. Most of the plants which were injured in this way recovered in a few weeks.

The use of ditolyl trichloroethane resulted in a similar leaf injury under the

Table 3.—Control of the orange tortrix on raspberries, Puyallup, Wash., 1948

FIELDS	MATERIALS	PRE-DUST POPULATION	NUMBER OF LIVING LARVAE PER 100 HILLS					
			5/6	5/27	6/24	7/14	7/27	Totals
A	1 Cryolite 61	32	14	0	2	37	30	83
	2 Sulfur—Cryolite 50–50	15	6	0	1	23	18	48
	3 Cryolite 50	14	6	0	2	26	19	49
	4 Methoxychlor 5[1]	14	6	0	0	63	21	90
B	1 Cryolite 50	6	0	0	0	2	1	3
C	1 Cryolite 50	7	4	0	0	4	6	14
	1 Cryolite 70[2]	2	0	0	1	15	2	18
D	2 Dichlorodiphenyl dichloroethane	0	0	0	0	1	0	1**

[1] These two plots received additional applications of methoxychlor during the picking season with results as indicated above.
[2] Highly significant figure as compared to 70 per cent cryolite dust.

Table 4.—Results of additional dustings on two plots (A4 and D1) listed in table 3.

MATERIALS	ADDITIONAL DUSTING DATES	PRE-DUST POPULATION	NUMBER LIVING LARVAE PER 100 HILLS			
			7/19	7/22	7/26	Totals
Methoxychlor 5	7/16	63	47	26	19	93
Cryolite 70	7/15	15	7	5	2	14

same conditions. This material was made safe by using the same precautions prescribed for dichlorodiphenyl dichloroethane.

A general yellowing of the raspberry foliage appeared following the application of a liquid chlordan formulation, apparently because of the emulsifying agent. The liquid formulations having the highest chlordan content were the safest. A wettable spray powder also appears to be safe.

NOTES ON BIOLOGY.—The late wet season in western Washington during 1948 undoubtedly kept the orange tortrix in check. Actively feeding larvae were found in the field in late March. Pupae were first observed by mid-April, becoming fairly numerous during the first week in May. The first orange tortrix adults were collected in the field around the middle of May, becoming most numerous in July and August.

Parasites of the orange tortrix were occasionally found in the fields as early as the middle of April. The degree of parasitism was as high as 50 per cent in some fields by the last week in July. Parasitism showed evidence of partial control in certain fields during the picking season. The most important species was determined as *Meteorus* n. sp. by C. F. W. Muesebeck.[1] Other parasites which were reared from the orange tortrix include: *Phytodietus vulgaris* Cr., *Ischnus atriceps* (Cr.), *Horogenes eureka* (Ash.), *Campoletis* sp., *Oncophanes atriceps* (Ashm.), and *Apanteles aristotoliae* Vier. (det. by Dr. H. K. Townes and C. F. W. Muesebeck). Lace-wing larvae, lady-beetle larvae, and spiders were also observed feeding upon orange tortrix larvae.

Orange tortrix larvae were collected and reared from the following host plants:

Red raspberry (*Rubus* hyb.)
Evergreen blackberry (*Rubus laciniatus*)
Youngberry (*Rubus* hyb.)
Boysenberry (*Rubus* hyb.)
Cascadeberry (*Rubus* hyb.)
Salmonberry (*Rubus spectabilis*)
Carnation (*Dianthus caryophyllus*)
Lemon (*Citrus limonia*)
Fuchsia (*Fuchsia* sp.)
Choisys (*Choisya ternata*)
Azalea (*Rhododendron sp.*)
Geranium (*Geranium sp.*)
Holly (*Ilex aquifolium*)
Kalanchoe (*Kalanchoe* sp.)
Begonia (*Begonia* sp.)
Scotch broom (*Cytisus scoparius*)
Strawberry (*Fragaria* hyb.)
Cork-bark oak (*Phellodendron* sp.)
Grape ivy (*Cissus rhombifolia*)
Rose (*Rosa* sp.)
Turnip (*Brassica rapa*)
Firethorn (*Pyrancantha* sp.)

About 100 actively feeding larvae were received from Dr. A. M. Boyce, Citrus Experiment Station, Riverside, California on June 23. These larvae had been collected at Whittier, California on lemon foliage. A portion were reared outside on caged raspberry plants. The change in climate and host plants apparently did not affect the larvae and most of the adults had emerged by July 19.

CONCLUSIONS.—All of the materials tested (cryolite, dichlorodiphenyl dichloroethane, ditolyl trichloroethane, chlordan, tetraethyl pyrophosphate, and parathion) gave some control of the orange tortrix, except tetraethyl pyrophosphate. Dichlorodiphenyl dichloroethane gave the most consistently good results and the best residual action. The following observations were made in the Puyallup area during the picking season:

1. In an area where the growers did a conscientious job of spraying using 5 to 7 cover sprays from early April until blooming time and using dichlorodiphenyl dichloroethane in at least one of the covers orange tortrix larvae were practically nonexistent during picking.

2. In another area, some growers did not adhere to a regular spray or dust schedule and dichlorodiphenyl dichloroethane was not used. Consequently, orange tortrix larvae appeared in the fields during harvest and a few fields had pickings rejected because of contamination.

Dichlorodiphenyl dichloroethane will be the mainstay in the recommendations for the control of orange tortrix in western Washington for 1949.

[1] Johansen, Carl. *Meteorus argyrotaeniae*, a New Species of Braconidae Parasitic on the Orange Tortrix. Annals of Entomological Society of America, V, XLII, N. 3, p. 319. September, 1949.

The Eye-Spotted Bud Moth on Prune in California

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The eye-spotted bud moth *Spilonota ocellana* (D. & S.) has been an important pest of apples in the northeastern states and in southeastern Canada for many years (1924). In California, the moth was not known to be present until 1926, when Borden reported it as a pest of apples in the Watsonville area. Since then, it has declined in importance in that area, and at the present time is of minor importance on apple. Mackie (1939) reported the moth as attacking plums and prunes in San Jose. Since that time, it has increased in importance in the prune growing areas of Santa Clara county until the damage to the crop has become of major importance. The moth has also spread to other prune growing areas of the coastal counties of California. At the present time, the most heavily infested area is in the Santa Clara Valley, which has almost half of the total prune acreage in the state, and nearly all the prune orchards are infested.

The damage to the prune crop is of two types. In the spring, the buds are attacked and destroyed, but this damage is probably of little importance economically as not enough buds are destroyed materially to affect the set of fruit. The summer generation of larvae, however, do cause considerable damage by attacking the fruit. Early in the season, the larvae are leaf feeders, but as the fruit enlarges and a considerable portion of the leaf is consumed, the larva ties the leaf to the fruit and feeds on the fruit from under this protection. The larvae do not enter the fruit, but feed on the surface, producing small shallow holes. Where attacked, the fruit produces considerable gum which cements the now dry leaf to the surface of the fruit. During processing, this leaf tissue is not removed, and the resulting dried fruit must be graded as a cull. In heavily infested orchards, the loss in grade may run as high as 40 to 50 per cent of the crop. In addition to the loss in grade, the sorting out of the damaged fruit adds greatly to the cost of production and lowers the net returns on the crop.

The moth is a very general feeder, and a large host list has been summarized by Porter (1924). In California, however, larvae have been taken only on prune, plum, apple, cherry, pear, and apricot. From observations made in the field, the preferred host seem to be prune, plum, cherry, and apple. The larvae were found attacking pear only in orchards adjacent to heavily infested prune blocks, and they caused only slight damage to the crop. Apricot does not seem to be a preferred host, as only an occasional larva was found even when the apricots were near heavily infested prune trees. No larvae were found on peach or any of the native trees found in association with deciduous fruits although some of these trees have been listed as hosts. Laboratory rearings of the larvae on the hosts mentioned above confirmed the observations noted in the field.

Under California conditions, the moth has one generation every 12 months, beginning with the egg stage in mid-summer and ending with the deposition of eggs for the next generation in mid-summer of the following calendar year. One generation per year seems to be the rule for the rest of the United States and Canada, as a number of authors have reported, among them Saunders & Dustan (1919) and Frost (1927). In California, the larvae pass through seven instars. The number of instars seems to vary with the locality, as Porter (1924) reports 6 instars from Connecticut, and Frost (1922) reports a total of 10 in Pennsylvania.

On prune, the moth winters as a fifth instar larva in a hibernaculum usually located at the base of a fruit spur. The larvae begin to construct their hibernaculae while in the fourth instar, and moult during the process, passing the winter in the fifth instar. Hibernation takes place during the month of September, and all of the larvae are in the overwintering quarters by the end of October. The great majority of the hibernaculae are constructed in the angle at the base of a fruit spur, but they may be located between the buds or at the base of a twig. Observations showed that 85 per cent of the hibernaculae are located on last season's wood, where the angle of the fruit spur to the twig is close to 45°.

When the buds of the prune trees begin

to swell in the spring, the larvae resume activity. They emerge from the hibernaculae when the buds are in the green tip stage and begin to feed. The opening buds are the first to be attacked, and the larvae burrow into the center of the buds, causing them to wither and die.

As the trees come into full bloom, the larvae tie the blossoms together with silk and feed on the petals and the developing ovary. Since only a small percentage of prune buds set fruit, the damage caused at this time is negligible. On cherry, however, this early damage is important, as it destroys blossom clusters that would

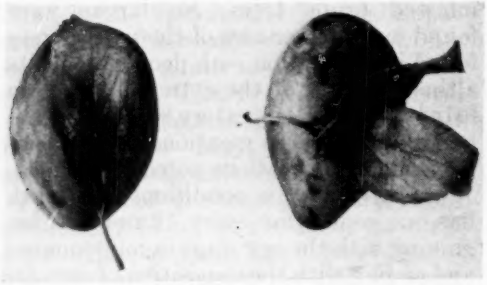

FIG. 1.—Damage to the fresh prunes caused by the eye-spotted bud moth.

normally set fruit. Fisher & Newcomer (1919), in Washington, state that this spring feeding causes the greatest damage to pears.

As soon as the leaves begin to expand, the larvae move to the terminal tips and tie several leaves together with silk forming a shelter in one of the leaves and feeding on the leaf tissue from within this protection. The leaf in which the shelter is constructed is either partially or completely severed at the base, and soon turns brown or black. This tied cluster of leaves with a brown or black leaf in the center is very charactersitic of the work of the eye-spotted bud moth. Often, the larvae will tie a developing fruit in the leaf cluster and feed on the fruit, causing deep scars. This fruit, however, drops from the tree and is not a factor at harvest.

During the early part of May, the larvae begin to pupate. According to Porter (1924) and Gilliatt (1927), the majority of the larvae pupate within the tied up leaf clusters in which they have been feeding. On prunes, however, they normally desert the leaf clusters and move back along the twig, where they construct a nest of dry leaves, bud scales or dried flower parts which is lined with silk. Observation showed that only 5 per cent of the larvae pupated within the tied up leaves. The duration of the pupal period varies from 10 to 20 days, the average being 16 days. The adult moths begin to emerge the latter part of May.

Bait pans, using a yeast diamalt mixture, were used to determine the length and peak of the moth flight. During the 1948 season, the peak flight was reached the early part of June, and moth flight continued to the early part of August. Twenty-four hour bait pan records were obtained during the peak flight, and light and temperature records were kept. The results showed that the moths begin to fly when the light intensity falls to 100 foot candles or less. If the temperature remained above 50° F., the moth flight continued all night, although the peak flight was reached between 10 and 11 P.M. (Daylight saving time). When temperatures fell below 50° F., moth activity ceased, and no further flight was noted.

Mating and egg laying takes place at night, and the eggs are deposited singly on both the upper and lower leaf surfaces. Sometimes as many as 5 to 6 eggs are laid on a single leaf, but more often only one egg is deposited per leaf.

The eggs hatch in 8 to 14 days, and the young larvae move to the undersides of the leaves along the midribs and begin to feed. As soon as a larva settles on a leaf, it constructs a silken shelter over itself and its feeding area, imbedding in the silk bits of frass and leaf tissue. Within the silken shelter, the larva constructs a tube consisting of frass and dry leaf tissue, lined with silk. The larva feeds on the leaf tissue from within this protection, and eats through to the epidermis of the opposite surface, which soon turns brown and dry. The silken shelter on the under side of the leaf, and the brown area on the upper surface is a characteristic sign of the work of the eye-spotted bud moth.

Later on in the season, as the feeding area is extended, the larva may tie the leaf on which it is feeding to another leaf with silk, or it may attach the leaf to a fruit. The damage to the prune crop occurs when the larva ties a leaf to a fruit and feed on the fruit surface from under this protection. The fruit produces con-

siderable gum where it is attacked, and the leaf is firmly cemented to the fruit (Fig. 1). The larvae are shallow feeders and cause small depressions or pits on the fruit surface. These pits are in themselves enough to cause the fruit to be graded as a cull, but the noticeable damage is caused by the leaf tissue which remains on the prune after it is processed and dried (Fig. 2). This fruit must be resorted and the affected fruits rejected as culls.

In the fall, the larvae desert the leaves and begin entering the winter quarters, which completes the life cycle.

The eye-spotted bud moth does no further damage to the prune crop after it has been processed and stored. Although the larvae are still present on the affected prunes when they are brought in from the field, the temperatures used in drying the prunes destroys the insects. No larvae were observed in any of the storage bins examined. Laboratory experiments showed that the larvae could not live on dried prunes, so there is apparently no danger of further injury to the dried prune crop.

In California, parasitism of the eye-spotted bud moth is very low. Counts of larvae in 1948 to determine the percentage of parasitism, showed only 2.3 per cent. All the parasites observed were larval parasites and emerged from the host just as the latter were preparing to pupate. Four species of parasites were collected and are as follows: *Meteorus ictericus* (Nees), *Apanteles aristoteliae* Viereck, *Brachymeria ovata* (Say), and *Exochus* sp. The *Meteorus* was by far the commonest species, and accounted for 90 per cent of the parasitism. The low percentage of parasitism in the field may be an important factor contributing to the abundance of the moth in California.

During the winter of 1947–1948, it was discovered that a predatory mite, *Pediculoides ventricosus* Newport, was attacking the larvae within their hibernaculae. The mortality of the larvae due to the attack of the mite reached as high as 50 per cent, as has been previously reported by Madsen (1948). During the winter of 1948–1949, however, a very different picture was found. Examination of hibernaculae in November and early December showed the mite present and apparently increasing in numbers, but the populations were lower than those of 1947–1948. Suddenly, however, the mite disappeared, and not a single mite was found the rest of the winter. As a result, the larval mortality during the winter months was greatly reduced. The only explanation that can be offered for the disappearance of the mite was the onset of freezing weather which lasted for several weeks. In contrast to this, the winter of 1947–1948 was very mild. Because of the lowered winter mortality of the larvae, the early season's attack of the eye-spotted bud moth in 1949 was very severe.

FIG. 2.—Damage to the dried prunes after processing. Note the leaf tissue remaining on the fruit.

CONTROL EXPERIMENTS.—During the fall of 1947, experiments were undertaken to find a control for the moth. The first sprays were applied as a post-harvest treatment on prunes, using 12 tree replicates. The materials used and the dosage per 100 gallons of water are as follows: 4 pounds of basic lead arsenate, 2 pounds of 50 per cent wettable DDT, 2 pounds of 50 per cent wettable xanthone 12, ounces of 15 per cent wettable parathion, and 2 pounds of 6 per cent gamma benzene hexachloride. Sprays were applied on September 4, using conventional ground equipment with 400 pounds pressure at the pump. Counts of the mortality of the larvae showed that parathion was the only material that gave adequate control. During the fall, when the larvae were in the hibernaculae, sprays were applied using parathion 15 per cent wettable at dosages of 2 pounds, 1 pound, and 8 ounces per 100 gallons of water. The sprays were applied on October 2, using 12 tree replicates, when all the larvae were in the winter quarters. Weekly counts were made of living and dead larvae within the hibernaculae and showed that the percentage mortality in the three blocks increased weekly up to 30 days after treatment. At that time, 100 per cent control was obtained with the 2 pound and

1 pound dosages, and 93 per cent with the 8 ounce dosage.

The results of the above experiments showed that parathion was a specific poison for the eye-spotted bud moth larvae, and would be effective as either a post harvest or a winter spray.

In the 1948 season, experiments were conducted using a number of the newer insecticides. Since the prune orchard used in the experiments had an infestation of tussock moth and fruit tree leaf roller,

Table 1.—Percentage infested prunes at harvest. 1948 season.

Material	Total No. Fruit Counted	Total No. Infested Fruit	Percentage Infested Fruit
Parathion	1498	9	0.27
Dichlorodiphenyl dichloroethane	1510	13	0.20
DDT	1651	115	7.0
Basic lead arsenate	1407	21	1.4
Toxaphene	1200	131	11.0
Check (no spray)	700	217	31.0

in addition to the eye-spotted bud moth, it was decided to spray twice, once in the jacket period to control the above pests, and again during the summer to control the new generation of bud moth. This last spray was timed to the hatching of the eggs. The plots were set up in a large French prune orchard located in the Santa Clara valley, near Saratoga. Twenty-four tree replicates were used and were sprayed April 20, and June 16, using the same ground equipment used in the previous tests. The materials used and the dosage per 100 gallons of water are as follows: 4 pounds basic lead arsenate, 2 pounds 50 per cent wettable DDT, 2 pounds 50 per cent wettable DDD, 2 pounds 50 per cent wettable toxaphene, and 1 pound 15 per cent wettable parathion. Approximately 8 gallons of spray was applied per tree in both the April 20 and June 16 applications.

Counts were made on the tied up leaf clusters following the April 20 application and showed the following percentage mortality: toxaphene 26 per cent, dichlorodiphenyl dichloroethane 94 per cent, basic lead arsenate 15 per cent, DDT 62 per cent, and parathion 100 per cent. Observations on the mortality of the fruit tree leaf roller showed good control on all blocks except the toxaphene and basic lead arsenate where control was poor.

Counts were made at harvest on the dropped fruit, and the results of the counts are summarized in table 1.

The above results show that parathion and dichlorodiphenyl dichloroethane were outstanding in the control of the eye-spotted bud moth. Satisfactory control was also obtained with basic lead arsenate. The latter material seems to be much more effective as a summer spray for the newly hatched larvae than in a jacket spray, as early season counts indicated only a partial control. This summer spray, to be timed when the eye-spotted bud moth eggs are 70 per cent or more hatched, is the most effective timing, although a jacket spray is necessary if other pests are a problem in the orchard. Although parathion and dichlorodiphenyl dichloroethane both gave excellent control of eye-spotted bud moth, spider mites became a major factor on the dichlorodiphenyl dichloroethane sprayed trees. Leaf drop was heavy in this block in contrast to the parathion sprayed trees which remained green throughout the season. Heavy defoliation due to spider mites also occurred on the DDT and toxaphene blocks.

Analysis of both the fresh fruit at harvest, and the dried fruit after processing was made on fruit from all of the sprayed blocks with the exception of toxaphene. The results of the analysis are shown in table 2.

Table 2.—Spray residue deposits in parts per million.

Material	Fresh Fruit	Dried Fruit
Basic lead arsenate	1.3	0.30
Dichlorodiphenyl dichloroethane	0.92	1.52
DDT	1.02	2.11
Parathion	.006	.007

The analysis shows that the lye wash used for prunes prior to processing, removes a good part of the lead arsenate deposit, but has no effect on residues of dichlorodiphenyl dichloroethane, DDT, or parathion. These residues are increased on the dried fruit due to the loss in weight after the drying process.

In the 1949 season, a large block of prune trees was used in order to test the relative efficiency of dichlorodiphenyl di-

chloroethane and parathion as both dusts and sprays. In conjunction with this, it was hoped that there would be striking differences in the spider mite populations between the blocks as in the previous season. A 22-acre block of prunes was treated. This block was divided into 8 plots, so that each treatment was replicated twice. In addition, a 5-acre check was set up near the treated blocks. Both the sprays and the dusts were applied in the jacket period, April 19, and during the egg hatching period in summer, June 14. The dichlorodiphenyl dichloroethane and parathion sprays were applied by means of spray rig with a 400 gallon tank, and a pump capacity of 80 gallons a minute. It delivers around 30,000 cubic feet of air per minute at a velocity of 110 miles per hours. Parathion 25 per cent wettable was used at the rate of 1 pound per 100 gallons, and dichlorodiphenyl dichloroethane 50 per cent wettable at the rate of 3 pounds per 100 gallons. The sprays were applied using the low volume method of spraying, which has been described by Borden (1948).

On the April 19 spray, a total of 170 gallons were applied per acre, or approximately 2 gallons per tree. The quantity was increased on the June 14 application to 228 gallons per acre, or 2.5 gallons per tree.

The dusts consisted of a 2 per cent parathion dust with attaclay as the carrier and a 5 per cent dichlorodiphenyl dichloroethane dust with talc as the carrier. Both dusts were applied with a Bean Vapo Duster. The parathion dust went on at a rate of 32 pounds per acre, and the dichlorodiphenyl dichloroethane dust at 40 pounds per acre. Fruit counts at harvest, made August 15, and August 28, showed the following percentages of bud moth damaged fruit: parathion spray 1.6 per cent, dichlorodiphenyl dichloroethane spray 0.5 per cent, parathion dust 3.7 per cent, dichlorodiphenyl dichloroethane dust 5.0 per cent, and untreated fruit 17.3 per cent. The spider mite populations did not increase sufficiently in any of the plots to cause defoliation in the late season as had occurred the previous year.

SUMMARY AND CONCLUSIONS.—The eye-spotted bud moth is an important pest of prunes in the Santa Clara valley and the prune growing counties of the coastal area of California.

The insect winters in hibernaculae constructed at the base of fruit spurs on second year wood. In the spring, the larvae emerge with the opening of the buds and feed on the buds and blossoms, which are tied together with silk. Later, they attack the unfolding leaves, and tie a cluster of leaves together with silk, feeding on the leaf tissue from within this shelter. Damage to the prunes is of minor importance at this time. The larvae desert the leaves and migrate back to the twigs in order to pupate. A pupation shelter of dry leaves, bud scales, or blossom parts is constructed, and pupation takes place the latter part of May. Moth flight occurs in May and June, mating and egg laying taking place at night. Observations showed that moth flight begins when the light intensity drops to 100 foot candles or below and flight will continue all night long if temperatures remain above 50° F.

Eggs are laid singly on both leaf surfaces, and hatch in 8 to 14 days. The young larvae feed on the lower leaf surfaces and construct tunnels of frass lined with silk. Later in the season, they will tie a leaf to a fruit and feed on the fruit surface from under this protection. The resulting shallow feeding holes and the gum that is produced cements the leaf to the fruit and accounts for the injury to the prune crop. In September and October, the larvae desert the leaves and construct the overwintering quarters.

Parasitism of the eye-spotted bud moth in California is very low. Only four species were collected and all were larval parasites. During the winter of 1947–1948, *Pediculoides ventricosus*, a predatory mite, destroyed up to 50 per cent of the larvae within their hibernaculae.

Three years control experiments showed that parathion at a dosage of 1 pound of the 15 per cent wettable or 12 ounces of the 25 per cent wettable, and dichlorodiphenyl dichloroethane at the rate of 2 pounds per 100 gallons gave excellent control. Of the two materials, parathion is to be preferred, as it destroys the spider mites which may become a problem in the late season. It is also effective against mealy plum louse, which is an important pest in the Santa Clara valley prune growing area. The most logical time to spray is during the summer months when the new generation larvae have appeared. The spray should be timed with the hatch-

ing of the eggs, the best time being when 70 per cent or more of the eggs have hatched. On prunes, however, where tussock moth, thrips, and fruit tree leaf roller are also problems, a jacket spray is necessary. In such cases, it should be followed by the summer spray in order to prevent any reinfestation by moths that fly in from adjoining unsprayed prunes or cherries. It has been shown that dusts of the above material will not be as effective as the wet sprays.

LITERATURE CITED

Borden, Arthur D. 1926. Some comparatively new apple insect pests in California. Pan. Pac. Ent. 3(2): 91–2.

Borden, Arthur D. 1948. Low volume spraying. California Agriculture 2(6): 5.

Fisher, D. F., and E. J. Newcomer. 1919. Controlling important fungous and insect enemies of the pear in the humid sections of the Pacific Northwest. U.S.D.A. Farm. Bul. 1056.

Frost, S. W. 1922. Ecdysis in *Tmetocera ocellana*. Ann. Ent. Soc. Amer. 15(2): 164–8.

Frost, S. W. 1927. Notes on the life history of the bud moth, *Spilonota ocellana* (D. & S.) Jour. Agr. Res. 35(4): 22–31.

Gilliatt, F. C. 1927. A preliminary report on some of the bud moths and leaf rollers of Nova Scotia. Ent. Soc. Ontario Ann. Rept. 58: 27–39.

Mackie, D. B. 1939. Twentieth annual report California Department of Agriculture. Calif. Dept. Agr. Bul. 10: 539–40.

Madsen, Harold F. 1948. *Pediculoides ventricosus*, a predatory mite attacking the bud moth. JOUR. ECON. ENT. 41(6): 984–5.

Porter, B. A. 1924. The bud moth. U.S.D.A. Department Bulletin 1273.

Saunders, G. E., and A. G. Dustan. 1919. The apple bud moths and their control in Nova Scotia. Canada Dept. of Agr. Bul. 16: 1–16.

Insecticides for the Control of Thrips on Onions Grown for Seed in Southern California

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Thrips have long been known to cause serious injury to onions grown for seed. They have reduced onion seed crops by as much as 50 per cent in years of severe infestation (Bailey 1938). Experiments and observations previous to 1945 had shown nicotine and tartar emetic to be ineffective in their control. Since the production of onion seed was of prime importance during the war, and as promising results had been obtained with DDT on bulb onions, experiments with DDT and other insecticides were begun on seed onions in 1945. The experiments were conducted on several varieties of onions being grown for seed, in the Coachella and Yucaipa Valleys in 1945 and in the Yucaipa Valley in 1947. The onion thrips, *Thrips tabaci* L., was the principal insect found damaging the plants before they headed, and the western flower thrips, *Franklinella californica* (Moulton)[1] together with the onion thrips, damaged the seed heads.

Other workers have reported good results from the use of DDT for the control of thrips on seed onions. Smith & Goodhue (1945) had excellent results from DDT aerosols on seed onion plants in the greenhouse. Peay & Sorenson (1946) reported increases in seed yield from DDT dusts. The New Mexico Agricultural Experiment Station (1945) reported good control of *Franklinella occidentalis* with DDT sprays and dusts, and a consequent increase in seed yields.

PROCEDURE.—All experiments were conducted on field plots arranged in randomized blocks. The experiments on schedules of application were made with dusts containing 10 per cent of DDT in pyrophyllite or in a mixture containing sulfur 25 per cent and pyrophyllite 65 per cent. The DDT dust was applied by rotary hand dusters to plots 4 or 8 rows wide and 40 or 50 feet long. In 1947, however, some of the fields contained plots 8 rows wide and 100 feet long, with 12-foot alleys between plots. These 100-foot plots were dusted by a power duster mounted on a pickup truck and equipped with a 12-foot boom on one side, which held one nozzle over each of 4 rows. The truck was driven down one side and back the other side of the 8-row plot to complete an application.

[1] Determined by J. C. Crawford.

As the seed stalks grew 2 to 4 feet high, alleys between the plots made possible the use of power equipment without causing serious damage. All dusts were applied at approximately 30 pounds per acre.

The insecticidal spray formulations were applied with a power sprayer. In preheading applications the sprayer straddled the rows in the usual manner and 3 nozzles were used per row. For use after the plants began to head the sprayer was equipped with a side boom which directed the spray to 5 rows through 2 nozzles to each row. The sprayer was moved in 12-foot alleys between the plots. In 1945 each spray plot consisted of 5 to 10 rows 240 to 660 feet long. All the sprays except the tartar emetic-sugar solution and those prepared from commerical wettable powders contained 12 ounces of phthalic glyceryl alkyl resin per 100 gallons.

In 1945 thrips on 4 plants per plot were counted at 3-week intervals before heading. In 1947 counts before heading were made at irregular intervals on 5 to 10 plants per plot. Counting thrips in seed heads was more difficult, but it was accomplished in the following manner: Four heads per plot were collected in pint mason jars about half filled with 30 per cent alcohol. They were brought to the laboratory, the alcohol was filtered in a suction funnel (111 mm. in diameter), and the thrips on the filter paper, which had previously been marked into quadrants, were counted under a binocular microscope. Most of the thrips were already out of the heads and in the alcohol, but when filtering was done any thrips remaining in the heads were washed out with alcohol.

Yield records were obtained by picking all the seed heads from parts of the plots. In the small plots 40 feet of row was harvested per plot in both years. In the large plots 100 feet of row was harvested per plot in 1945, and 80 feet in 1947. The seed was put in sacks and dried on the roof at the laboratory, with occasional turning. The small samples were threshed by hand, and the larger samples by machine. In 1945 the seed was further cleaned by immersing it in water, and the chaff and floating seeds were skimmed off the top. In 1947 the seed was threshed by machine without further cleaning.

Germination tests were run on 300 seeds per plot in 1945 and on 100 seeds per plot in 1947. Yields per acre were computed on the basis of 100 per cent germination.

CONTROL BY APPLICATIONS BEGINNING BEFORE HEADING.—An experiment was conducted at Yucaipa in 1945 with sprays applied during both the pre-heading and the heading stages of the onions. There were three replicates, two on White Bermuda and one on White Grano onions. The only untreated onions were three rows of the White Bermuda variety. The preheading applications were made on April 16 and 30, at about 175 gallons of spray per acre-application. Applications were also made to the seed heads on May 26, June 5, 12, 19, and 25 and July 2, at 130 to 150 gallons per acre-application. The spray treatments and results are summarized in table 1.

For pre-heading sprays DDT was superior to tartar emetic and nicotine against both larvae and adults, but there was no difference between the several DDT sprays. Nicotine was superior to tartar emetic in control of larvae, and tartar emetic was superior in control of adults.

Counts of thrips made at irregular intervals during the heading period showed that the DDT sprays were superior to the tartar emetic and nicotine sprays, and that tartar emetic was superior to nicotine. These data verified the results from the preheading applications. In seed yield there was no significant difference between spray treatments. The sprayed plots yielded from 405 to 545 more pounds of viable seed per acre than the untreated plot. At $1.50 per pound, this increase would mean a gain of from $607 to $817 per acre, less the cost of spraying.

In another experiment at Yucaipa in 1945, 10-per cent DDT dust was applied at 1- and 2-week intervals during the preheading period from February 27 to April 4. Thrips counts made on February 26 showed an average population of 19 nymphs and 6 adults per plant in the untreated plots. Subsequent examinations at 3-week intervals showed a marked reduction in thrips population in the untreated as well as in the treated plots. The cool weather and frequent rains reduced the population to such a low point that no plant damage was evident. No differences in seed-stalk height, seed-head diameter, and seed yield were seen between the treated and untreated plots.

In 1947 another opportunity was afforded for the study of the effectiveness of preheading applications of DDT dust. It was in connection with an experiment in the Yucaipa Valley on the timing of DDT dust applications to early Texas Grano onions during the heading period. In this experiment no regular schedule of preheading applications was planned, other than to dust alternate block-replicates if and when the thrips populations field, and that on such a valuable crop to permit such loss would be unfair to the grower. Consequently, the entire field, except the check plots, was treated on March 5. This procedure provided an additional experiment of four treatments with three replicates each. Thrips control was fair to good (Table 2), and held the population at a comparatively low level until March 31, when the last count of thrips was made.

Table 1.—Control of onion thrips with spray applications of several insecticides on White Grano and White Bermuda seed onions in the preheading and heading stages. Yucaipa, Calif., 1945.

Insecticide (Quantities in 100 Gal. of Spray)	Thrips per Plant Before Heading, May 7		Thrips per Seed Head			Yield per Acre
	Larvae	Adults	June 4	July 2	July 9	
	Number	*Number*	*Number*	*Number*	*Number*	*Pounds*
DDT from fused DDT-sulfur dust preparation:						
1 lb.	0	0.2	38	44	92	877
1.5 lb.	0	0.0	17	34	77	893
DDT from emulsion in toluene, 1 lb.	0	0.3	12	47	90	852
Tartar emetic 4 lb., plus sugar 4 lb.	3.7	1.7	38	121	155	862
Nicotine sulfate (40% nicotine) 1 qt., plus sugar 4 lb.	1.1	3.0	75	190	200	753
Difference required for significance (odds 19:1)	1.3	1.1	22	36	42	[1]
Check (unreplicated)	21.5	7.5	180	256	288	348

[1] Not significant by *F* test.

Table 2.—Control of onion thrips on seed onions with 10 per cent DDT dust (with sulfur 25 per cent) applied at different times during the preheading period. Early Texas Grano Onions, Yucaipa, Calif., 1947

Dates of Applications[1]	Dosage of Dust per Acre (Pounds)	Larvae					Adults					Seed Heads Blasted (Per Cent)	Seed Stalks per 20 Feet of Row	Seed-Stalk Height	Seed-Head Diameter	Germination (Per Cent)	Pound Seed per Acre
		Feb.	March				Feb.	March									
		26	5	12	24	31	26	5	12	24	31						
														Inches			
Feb. 19	30	11	13	20	15	46	4	3	7	7	12	0	139	33.2	2.4	73	261
Feb. 19 and Mar. 5	60	—	—	4	4	22	—	—	4	2	8	0	131	31.0	2.4	67	196
Mar. 5	30	—	—	11	16	57	—	—	16	4	15	0	107	27.6	2.2	52	122
Check (no treatment)	—	77	78	83	90	196	9	8	31	30	39	7.8	108	22.0	1.9	48	94
Difference required for significance (odds 19:1)	—	—	—	18	17	33	—	—	6	10	10	2.2	[2]	1.2	0.3	18	69

[1] In addition, all plots, including check, received 6 applications at weekly intervals during the heading period.
[2] Not significant by the *F* test.

warranted it. However, observations during February showed a decided thrips build-up in these onions (Fig. 1), and so half the blocks were treated with 10 per cent DDT dust on February 19, when there were an average of 38 larvae and 4 adults per plant. As the population continued to increase in the next 2 weeks, it seemed probable that severe damage might occur in the untreated half of the

Subsequent measurements of plant growth and crop yield showed significant differences between the treated and untreated plots. There was also a significant difference in the percentages of blasted heads, but the difference in number of stalks per 20 feet of row was not significant. Apparently no untreated plants were killed outright by thrips injury. In the average height of seed stalks and diameter

of seed heads, the treatment on February 19 was significantly better than the one treatment on March 5, and the March 5 treatment was superior to no treatment. Two applications showed no improvement over the first application alone. That similar results were obtained in seed germination and seed yield emphasizes the importance of early application for control of thrips. A delay of 2 weeks in the preheading application resulted in inferior plant growth and seed yield.

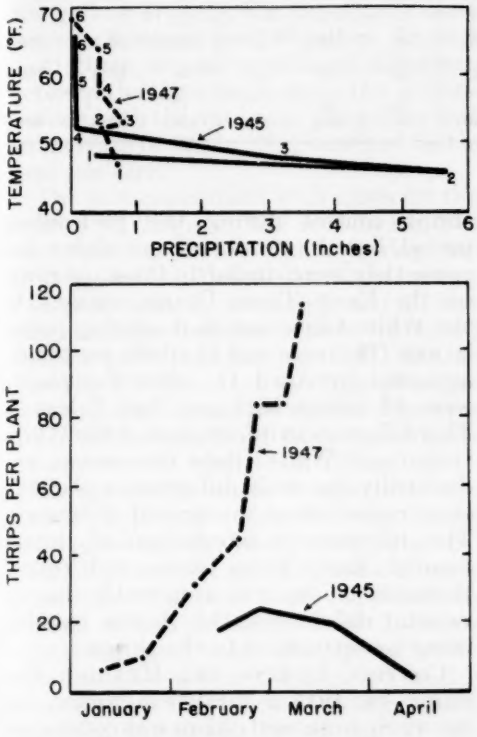

FIG. 1.—Effect of temperature and precipitation on thrips populations on untreated seed onions before heading, Yucaipa, Calif., 1945 and 1947. Above, climograph for the first 6 months of each year. Below, number of thrips per plant at irregular intervals during the first 4 months of each year.

Comparisons of weather conditions in 1945 with those in 1947 indicate both temperature and precipitation to be responsible for the difference in thrips populations, although temperature was probably more important (Fig. 1). For January little difference was apparent between 1945 and 1947. For February the mean temperature was 5° higher and the rainfall nearly 3 inches less in 1947 than in 1945. For March the mean temperature was 7° higher and the rainfall nearly 5 inches less in 1947. Thrips populations decreased in March 1945 and increased in March 1947.

Five varieties of onions being grown for seed at Yucaipa were observed during the preheading period in 1947. The difference in thrips development on the Early Texas Grano and Brown Spanish onions was apparently due to varietal preference, whereas the differences between the other varieties were due to plant size or to planting dates.

These two varieties of onions were considered to have equal opportunities for growth, although planted at different times. The Early Texas Grano onions were planted in November 1946, and the Brown Spanish onions were planted in the fall of 1945 and left in the soil for a second crop in 1947. Plant growth and development in these two varieties were similar up to March, but thrips develop-

Table 3.—Thrips development and plant growth on two varieties of seed onions during the preheading period. Yucaipa, Calif., 1947.

	Early Texas Grano					Brown Spanish				
	Thrips per Plant		Plant Development			Thrips per Plant		Plant Development		
Date	Larvae	Adults	Leaf Height (inches)	Seed-Stalk Height (inches)	Leaves per Plant	Larvae	Adults	Leaf Height (inches)	Seed-Stalk Height (inches)	Leaves per Plant
Jan. 23	6.5	3.6	9.6	—	4.7	5.4	2.4	12.1	—	4.0
Feb. 6	18.4	6.4	12.3	—	5.0	4.8	4.4	14.4	—	5.1
19	37.8	4.4	13.2	—	5.5	9.3	3.8	14.7	—	4.9
Mar. 5	77.6	7.7	14.5	—	6.4	10.3	5.8	17.0	—	6.0
24	89.8	30.1	15.3	4.7	6.9	22.4	7.8	19.6	7.9	6.2
31	196.3	38.7	15.5	8.2	7.1	—	—	—	—	—
Apr. 9	—	—	—	—	—	37.6	8.4	19.9	16.9	5.9

Table 4.—Control of onion thrips with DDT sprays applied during the heading period of Brown Spanish seed onions, Yucaipa, Calif., 1945.

Formulation (Quantities in 100 Gal. of Spray)		Dosage of Spray per Acre per Application	Thrips per Head					Seed Germination	Seed Yield per Acre
DDT	Spreading Agent		June 12	July 2	July 9	July 17	Average		
		Gallons	*Number*	*Number*	*Number*	*Number*	*Number*	*Per Cent*	*Pounds*
10% fused in sulfur, 1 lb.	Phthalic glyceryl resin, 12 oz.	149	54	19	49	12	33	95.2	703
10% fused in sulfur, 0.5 lb.	Phthalic glyceryl resin, 12 oz.	138	79	61	80	17	59	96.5	776
20% wettable powder, 1 lb.	Proprietary mixture, 12 oz.	141	45	40	56	11	38	95.5	758
Difference required for significance (odds 19:1)		—	[1]	32	23	[1]	17	[1]	[1]
Check no treatment)		—	109	187	226	6	132	93.8	602

[1] Not significant according to *F* test.

ment was radically different (Table 3). On the Early Texas Grano onions damaging numbers of thrips (38 larvae and 4 adults per plant) were found on February 19, when the plants were 13 inches high and had 5.5 leaves but no seed stalks. On Brown Spanish onions similar populations were not reached until April 9, when the plants were 20 inches high and had 5.9 leaves and seed stalks 17 inches high. This population was not considered damaging on onions of this size.

On Yellow Bermuda onions, which were also planted in the fall, damaging populations (23 larvae and 14 adults per plant) developed by February 28, when the plants were 7.6 inches high and had 5.8 leaves.

On White Grano onions planted in January 1947 and White Globe onions planted in February 1947, infestations developed later in the season, mainly because of slower and later growth. On White Grano onions a damaging population (26 nymphs and 8 adults per plant) developed by March 24, when the plants were 10 inches high and had 8 leaves. Experimental plots in this field demonstrated the value of thrips control during the preheading period, but the results are not shown because they were similar to those obtained on the Early Texas Grano onions. On the White Globe onions damaging populations (19 larvae and 13 adults per plant) appeared by April 11, when the plants were 12 inches high and had 7 leaves. This difference in infestations of the White Grano and White Globe onions was undoubtedly due to the difference in planting time rather than to varietal difference. The difference in infestations of Brown Spanish, Early Texas Grano, and Yellow Bermuda onions was apparently due to varietal differences, the Brown Spanish being less attractive to the thrips.

CONTROL DURING THE HEADING PERIOD.—In 1945 a spray experiment on Brown Spanish seed onions was conducted at Yucaipa in plots 10 rows wide and 250 to 443 feet long. There were five plots for each treatment and two check plots. The sprays contained commercial DDT preparations, and 12 ounces of spreading agent per 100 gallons. The spreading agent used with the DDT fused in sulfur was phthalic glyceryl alkyl resin, and that

Table 5.—Control of onion thrips on seed onions with 10 per cent DDT dust applied at different times during the heading period. Yellow Bermuda onions, Indio, Calif., 1945.

Time of Applications	Dosage of Dust per Acre	Thrips per Head			Seed-Stalk Height with Heads Closed	Seed Yield per Head
		Apr. 12	Apr. 24	May 2		
	Pounds	*Number*	*Number*	*Number*	*Inches*	*Ounce*
Each of first 3 weeks	93	49	29	94	30	0.058
Each of first 6 weeks	191	56	31	86	30	.059
First, third and fifth weeks	91	67	37	103	28	.059
Check (no treatment)	0	107	44	81	26	.048
Difference required for significance (odds 19:1)	—	17	[1]	[1]	3	.008

[1] Not significant according to the *F* test.

used with the wettable powder was a proprietary mixture of unknown composition. Six applications were made at weekly intervals, on May 29, June 4, 12, 18, and 25, and July 2. The results are shown in table 4.

In thrips control 1 pound of DDT per 100 gallons of spray was superior in most cases to 8 ounces per 100 gallons. In crop yield there was no significant difference between the three treatments, but in comparison with the untreated plots there was an increase of 101 to 174 pounds of viable seed per acre.

The first experiment with dusts for the control of thrips in the seed heads was conducted at Indio, Calif., during the 1945 season on Yellow Bermuda onions. The plots were 5 rows wide and 43 feet long, and the treatments were replicated eight times. Ten per cent of DDT in pyrophyllite was used at 30 pounds per acre-application, and the applications were made with rotary hand dusters on March 20 and 28, and April 4, 10, 17, and 25.

Thrips counts made 2 days after the fourth application showed significant differences between the treated and untreated plots, but counts made a week after the fifth and sixth applications showed no such difference (Table 5). These counts indicated that the thrips redistributed themselves over the field in a week's time during the warm weather which prevailed during this period. Larval control on the plants from these applications resulted in increased height of the seed stalks on which heads opened late, but showed no difference in the seed stalks on which heads opened earlier, or in the diameter of these seed heads. Comparisons were based on 100 seed heads per plot, dried and cleaned in the usual manner. All treated plots showed a significant increase in yield over the untreated plots, but there was no significant difference between the treatments. Germination ranged from 91 to 93 per cent, with no significant difference between treatments.

In an experiment on White Grano seed onions at Yucaipa in 1945, 6 weekly applications of 10 per cent DDT dust were made during the heading period by hand dusters on plots 4 and 5 rows wide and 43 feet long. There had been a low population of thrips on the plants prior to heading. However, on May 1, when the applications to the seed heads were begun, the western flower thrips were found to be migrating to the onion heads from chaparral blossoms which were maturing at this time. The DDT dust reduced the numbers of adult thrips but did not significantly affect the plant growth and seed yield as compared with undusted plots.

In 1947 the applications at Yucaipa were made over a 9-week period. Some of the applications were made only over one 3-week period to determine, if possible, what was the most critical period for thrips control and seed-head protection. These experiments were conducted on small plots of Early Texas Grano and White Grano onions.

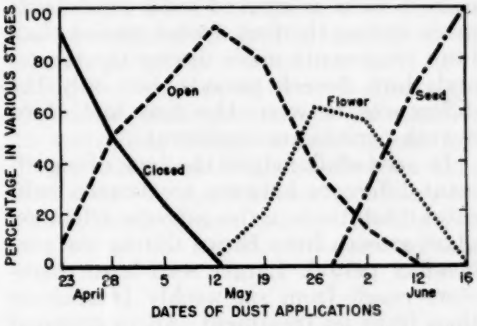

FIG. 2.—Percentages of the seed heads in the various developmental stages throughout the dusting season. Early Texas Grano seed onions, Yucaipa, Calif., 1947.

On Early Texas Grano seed onions the dust applications were started on April 23. At this time only 10 per cent of the seed heads had opened (Fig. 2). By the fourth week 3 per cent of the seed heads were closed, 93 per cent open, and 4 per cent were in flower. By the seventh week 14 per cent were open, 57 per cent in flower, and 29 per cent had formed seed. By the ninth week all the heads had formed seed.

Thrips counts were made at the start of treatment and at the end of each 3-week period (Table 6). Thrips populations were not especially high in this field, ranging from 76 to 118 per head in the untreated plots. On the basis of counts made 1 week after the last application, three applications gave 65 to 80 per cent control and six applications 87 per cent.

Data on plant growth, seed harvest, and germination are shown in table 6. These data are combined from three replicate plots treated on February 19

Table 6.—Control of onion thrips with 10 per cent DDT dust (with sulfur 25 per cent) applied during different portions of the heading period. Early Texas Grano seed onions, Yucaipa, Calif., 1947.

Time of Applications	Pounds of Dust per Acre	Thrips per Head			Per Cent Blasted Heads	Seed-Stalk Height (Inches)	Seed-Head Diameter (Inches)	Per Cent Germination	Pounds Seed per Acre	Net Profit Over Check (Dollars per Acre)
		May 12	June 2	June 23						
First, second, and third weeks	91	24	55	78	1.7	31	2.4	78	297	225
Fourth, fifth, and sixth weeks	85	—	24	48	6.9	30	2.2	73	261	162
Seventh, eighth, and ninth weeks	96	—	—	27	12.6	31	2.3	77	273	183
Each of first 6 weeks	172	—	15	99	1.7	32	2.4	79	319	247
Check (no treatment)	—	98	118	76	15.8	29	2.2	60	159	—
Difference required for significance (odds 19:1)		32	34	48	7.1	2	0.2	12	66	116

and three treated on March 5, during the preheading period.

In the prevention of blasted heads, more benefit is derived from treatments made during the first 3-week period than from treatments made during the second and third 3-week periods, but only the differences between the first and third 3-week periods are significant.

In seed-stalk height the lack of significant difference between treatments indicates that there is no adverse effect on plant growth from thrips during the preheading period. Larger seed-head diameters result from six weekly treatments than from no treatment. All the treated plots gave a higher percentage of germination and larger yield than did the untreated plots. Better results were obtained from six applications than from three applications, but the differences were not significant.

The plots receiving three and six applications gave net profits over the check plot in excess of those attributed to experimental error. These profits were calculated on the basis of the contract selling price of $1.75 per pound for viable seed, and the purchasing price of 14 cents per pound for DDT dust. The cost of application was estimated to be 4 cents per pound. There were no significant differences in profits from three applications and six applications.

Outstanding results were obtained in the portion of the field not included in the experimental layout, which received both the preheading applications as well as all nine heading applications. This portion of the field produced 484 pounds of viable seed per acre and showed a net profit of $520 per acre over the untreated portion.

A similar experiment on White Grano onions at Yucaipa in 1947 gave corresponding results from both the preheading and the heading applications.

Most of the dusts tested in the experiments discussed were also applied with a power duster to four plots of Brown Spanish onions at Yucaipa in 1947. Applications to the seed heads were started on May 5, when only 44 per cent of the heads were open. Thrips counts made at 3-week intervals throughout the heading period are shown in Table 7. Thrips control was poorer in this field than in the hand-dusted fields, and ranged from 53 to 66 per cent 1 week after the termination of a series of three applications. After six applications it was 71 per cent, and after nine applications 74 per cent. The differences in plant development between treated and untreated plots were not significant. Increases in seed yield in the treated plots were evident but not significant. Definite benefits from spray applications on this variety of seed onions were obtained in 1945 (Table 4).

Similar results were obtained in four

Table 7.—Control of onion thrips with 10 per cent DDT dust (with sulfur 25 per cent), applied by power dusters during the heading period. Brown Spanish onions, Yucaipa, Calif., 1947.

Time of Applications	Pounds of Dust per Acre	Thrips per Head			
		May 12	May 26	June 16	July 7
First, second and third weeks	137	—	30	180	22
Fourth, fifth, and sixth weeks	87	—	—	76	23
Seventh, eighth, and ninth weeks	75	—	—	—	22
Each of first 6 weeks	224	—	—	65	19
Each of first 9 weeks	299	—	—	—	13
Check (no treatment)	—	82	64	223	51
Difference required for significance (odds 19:1)	—	—	[1]	86	23

[1] Not significant by the *F* test.

plots of White Globe onions treated at the same time and in the same manner as the Brown Spanish onions. Increased yields in the treated plots were not significant, owing to late planting and an uneven stand of plants.

SUMMARY.—Experiments with insecticides for the control of thrips on onions grown for seed were conducted in southern California during 1945 and 1947. A 10 per cent DDT dust was used on small plots, applied by hand dusters in both years and by power dusters in 1947. DDT and other sprays were used on large plots in 1945. Applications were made both before seed heads had formed and after they had opened.

Preheading tests conducted in 1945 showed no benefit in plant growth or seed yield because of low thrips populations. In 1947, plots dusted during the preheading period showed marked improvement in plant growth and seed yield in comparison with untreated plots. Both temperature and precipitation were more favorable for thrips development in 1947 than in 1945. In 1947 Brown Spanish onions were less susceptible to thrips injury during the preheading period than were Early Texas Grano, Yellow Bermuda or White Grano varieties.

Spray tests in 1945 showed that DDT (1 and 1.5 lb. per 100 gal) was more effective than tartar emetic (4 lb. per 100 gal.) or nicotine sulphate (1 lb. per 400 gal.). Tartar emetic was more effective than nicotine in control of adults, and nicotine was more effective than tartar emetic in control of larvae. Plots sprayed six times at weekly intervals produced 101 to 545 pounds more seed than did the untreated plots.

A DDT dust applied to the seed heads while they were opening and after they had opened, over a 6-week period in 1945 and a 9-week period in 1947, showed best results when applied weekly at 30 pounds per acre.

Most of these tests have demonstrated that DDT dusts and sprays are effective in controlling thrips on seed onions and give decided benefits in seed production. The cost of applications necessary to obtain the best results is not prohibitive, in view of the benefits obtained in seed yield.

LITERATURE CITED

Bailey, S. F. 1938. Thrips of economic importance in California. Calif. Agr. Expt. Sta. Cir. **346**: 44–50.

New Mexico Agricultural Experiment Station. 1945. Report of the Biology Department. N. M. Agr. Expt. Sta. Ann. Rpt. **56** 1944–45: 44–8.

Peay, W. E., and C. J. Sorenson. 1946. Yield of onion seed increased by thrips control. Utah Agr. Expt. Sta. Farm and Home Science **7**(2): 12.

Smith, Floyd F., and L. D. Goodhue. 1945. DDT aerosols to control onion thrips and other pests in greenhouses. JOUR. ECON. ENT. **38**(2): 173–9.

Wilcox, J., and A. F. Howland. 1948. DDT dust for control of onion thrips. JOUR. ECON. ENT. **41**(5): 694–700.

KANSAS ENTOMOLOGICAL SOCIETY

The Kansas Entomological Society held its twenty-fifth meeting at the Kansas State College on April 30, 1949. Approximately 125 entomologists were in attendance to listen to thirty-eight papers. These were on such subjects as the western corn-root worm, the southwestern corn borer, ectoparasite recovery, *Strepsiptera*, *Typhlocyba*, *Dikraneurini*, *Osmia*, bees, feeding mechanism of horseflies, imbedding insects in plastic, insecticide studies, stain techniques, moth proofing tests, horn fly control, etc. The program was well balanced and not overburdened with insecticide papers. In fact most of the papers were devoted to taxonomy, morphology, biology, behavior, and other non-economic topics.

Tests of Some New Insecticides to Control Mexican Bean Beetle

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The experiments reported in this paper were conducted at Norfolk, Va., during 1947 to determine the comparative effectiveness of several new insecticides and insecticide formulations in dust mixtures for the control of the Mexican bean beetle, *Epilachna varivestis* Muls. One of the materials tested was piperonyl cyclonene reported by Brannon (1947) to be a synergist with pyrethrum and rotenone for this insect. The piperonyl cyclonene was mixed with sabadilla, which Fisher & Stanley (1945) reported to be toxic to the Mexican bean beetle; with DDT reported by White (1946) to be relatively ineffective; and with methoxychlor, which has given promising results against the insect (Brannon 1947). Other materials included toxaphene, previously tested by Stearns *et al.* (1947), hexaethyl tetraphosphate, benzene hexachloride, chlordan, and parathion.

PROCEDURE.—Four experiments were conducted on Bountiful snap beans in 4-row plots, 12 feet wide. The plots for the various treatments were randomized in four blocks, so that each treatment occurred once within each block. Each block also contained one undusted plot. In experiments 1 and 3 the rows were 80 feet long and the dusts were applied with a 4-row power duster equipped with 8 "scoop" nozzles (2 to each row) of the type generally used against the Mexican bean beetle, and a light cloth trailer extending approximately 12 feet to the rear. In experiments 2 and 4 the rows were 36 feet long and the dusts were applied with bellows-type hand dusters to each side of the row, so that the undersurfaces of the leaves were covered.

Most of the dust mixtures were prepared in the laboratory by diluting commercial insecticide concentrates with pyrophyllite. The 0.5-per cent parathion dust, however, was used as it was received from the manufacturer. The concentrate for the pyrethrum-piperonyl cyclonene dust was a proprietary mixture containing pyrethrum marc impregnated with 2.5 per cent of piperonyl cyclonene and sufficient pyrethrum extract to furnish 0.4 per cent of pyrethrins. The piperonyl cyclonene used in the other dust mixtures was derived from a commercial dust concentrate containing 2.5 per cent of piperonyl cyclonene on walnut-shell flour. The concentrate for the sabadilla dusts was a mixture of equal parts of sabadilla and hydrated lime, and for the rotenone dusts a cube powder containing 3.6 per cent of rotenone and 13.5 per cent of total extractives.

In experiment 1 applications were made on May 21, 27, and June 10. Within 31 hours after the first application 0.56 inch of rain fell. No rain fell within 7 days after the second application or within 3 days after the third. At the time of the first application the plants contained small first and second trifoliate leaves and at the time of the third the plants were blooming and setting small pods. Counts of Mexican bean beetles made on the four random undusted plots just prior to the first application indicated an average infestation of 9 beetles, 7 egg masses, and 5 batches of young larvae on 6 feet of row.

Applications in experiment 2 were made on July 15, 21, and 28, and on August 5. It rained shortly after each application, the precipitation being 0.17, 1.27 and 0.14 inches within 10 hours after the first, second, and third applications, respectively, and 0.85 inch about 38 hours after the fourth application. At the time of the first application the plants contained small first trifoliate leaves, and at the time of the fourth the plants were blooming and setting small pods. Counts of Mexican bean beetles made on the 4 random undusted plots 1 day prior to the first application indicated an average infestation of 8 beetles and 2 egg masses on 6 feet of row.

Applications in experiment 3 were made on August 27 and on September 3 and 10. Within 19 hours after the first application 1.22 inches of rain fell. Rainfall amounting to 0.45 inch occurred 67 hours after the second application. No rain fell within 72

[1] Died February 23, 1948.
[2] In cooperation with the Virginia Truck Experiment Station.

Table 1.—Effectiveness of dust mixtures for control of the Mexican bean beetle.

DUST MIXTURES (PER CENT BY WEIGHT INGREDIENTS IN PYROPHYLLITE)	POUNDS PER ACRE	BUSHELS PER ACRE[1]	LARVAE AND PUPAE SURVIVING ON 10 PLANTS[2]	PER CENT CONTROL OF LARVAE
Experiment 1 (3 Applications)				
Rotenone 0.45, DDT 3, sulfur 50	32	—	2	98
Toxaphene 5	30	—	18	85
Hexaethyl tetraphosphate 3	30	—	36	70
Chlordane 5	32	—	69	42
Check (undusted)	—	—	119	—
Difference required for significance (odds 19:1)	—	—	20	—
Experiment 2 (4 Applications)				
Pyrethrum (pyrethrins 0.08), piperonyl cyclonene 0.5, sulfur 25	23	131	29	90
Parathion, 0.5	20	125	46	85
Toxaphene 10, sulfur 25	26	114	77	75
Check (undusted)	—	58	308	—
Difference required for significance (odds 19:1)	—	19	31	—
Experiment 3 (3 Applications)				
Methoxylor 3, piperonyl cyclonene 0.5, sulfur 50	30	137	36	78
Methoxychlor 3, sulfur 50	31	123	40	76
DDT 3, sulfur 50	30	127	74	56
DDT 3, piperonyl cyclonene 0.5, sulfur 50	30	98	109	35
Check (undusted)	—	42	167	—
Difference required for significance (odds 19:1)	—	[3]	36	—
Experiment 4 (2 Applications)				
Rotenone 0.5, DDT 3, sulfur 50	23	—	27	79
Sabadilla 10, piperonyl cyclonene 0.5, sulfur 50	24	—	88	18
Sabadilla 10, sulfur 50	25	—	93	13
Check (undusted)	—	—	107	—
Difference rquired for significance (odds 19:1)	—	—	16	—

[1] The beans were picked on August 18 and September 2 in experiment 2 and on September 16 and 26 in experiment 3.
[2] Insect counts were made 1 to 2 weeks after the last application.
[3] Not significant by the *F* test.

hours after the third application. At the time of the first application the plants were budding, and at the time of the third they were in bloom and beginning to form small pods. Counts of Mexican bean beetles made on the four random undusted plots 1 day prior to the first application indicated an average infestation of 22 beetles, 12 egg masses, and 1 batch of young larvae on 6 feet of row.

Applications in experiment 4 were made on September 30 and October 6. No rain fell between the first and second applications; however, 0.60 inch fell 25 hours after the second application. At the time of the first application the plants were just beginning to bloom, and at the time of the second they were in full bloom and beginning to form small pods. Mexican bean beetle adults entered the plots in large numbers soon after the beans came up and shortly thereafter egg masses were very numerous on the plants. At the time of the first application second- and third-instar larvae were very numerous on the plants and larval injury to the foliage was visible from a distance.

RESULTS.—The results of the experiment are presented in table 1. In experiment 1 a dust mixture containing 0.45 per cent of rotencne, 3 per cent of DDT and 50 per cent of sulfur was more effective against the Mexican bean beetle than either 5 per cent chlordan or 3 per cent hexaethyl tetraphosphate. Results with toxaphene were superior to those obtained with chlordan of the same strength. Freshly mixed hexaethyl tetraphosphate gave considerable protection against the insect, but was not so effective as either rotenone or toxaphene.

In experiment 2 a dust containing 0.08 per cent of pyrethrins and 0.5 per cent of piperonyl cyclonene was more effective against the bean beetle than a 10 per cent toxaphene dust. The commercial 0.5 per cent parathion dust was almost as effective as the pyrethrum-piperonyl cyclonene dust. A 10 per cent toxaphene dust was less effective than the pyrethrum-

piperonyl cyclonene dust, but gave a substantial increase in yield as compared with undusted plots.

In experiments 3 and 4 piperonyl cyclonene was ineffective in increasing the toxicity of dust mixtures containing methoxychlor, DDT, or sabadilla. All of these mixtures, with and without piperonyl cyclonene, contained 50 per cent of sulfur. The methoxychlor at 3 per cent strength gave fairly good control, whereas the control with 10 per cent sabadilla was not appreciable.

SUMMARY AND CONCLUSIONS.—In experiments conducted at Norfolk, Va., in 1947 against the Mexican bean beetle on snap beans, rotenone mixed with DDT and sulfur dust was more effective than chlordan or freshly mixed hexaethyl tetraphosphate. A dust mixture containing 0.08 per cent of pyrethrins and 0.5 per cent of piperonyl cyclonene was more effective against the pest than a 10 per cent toxaphene dust.

A commercial 0.5 per cent parathion dust was almost as effective as a pyrethrum-piperonyl cyclonene dust containing 0.08 per cent of pyrethrins and was more effective than a 10 per cent toxaphene dust.

Piperonyl cyclonene did not increase the control of the Mexican bean beetle when mixed with dusts containing DDT, sabadilla, or methoxychlor.

LITERATURE CITED

Brannon, L. W. 1947. Further tests for control of Mexican bean beetle and corn earworm on snap beans. JOUR. ECON. ENT. 40(1): 103–6.

Brannon, L. W. 1947. Piperonyl cyclonene and piperonyl butoxide as synergists with rotenone. JOUR. ECON. ENT. 40(6): 933–4.

Fisher, E. H., and W. W. Stanley. 1945. Preliminary tests with sabadilla. JOUR. ECON. ENT. 38(1): 125–6

Stearns, L. A., W. LeRoy Parker, Donald McCroary, and W. A. Connell, 1947. A chlorinated bicyclic terpene used to control certain fruit and vegetable insects. JOUR. ECON. ENT. 40(1): 79–83.

White, W. H. 1946. Summary of results with DDT against truck crop, tobacco, and sugar beet insects during 1945. U. S. Bur. Ent. and Plant Quar. Cir. E-692.

Corn Earworm Control with Insecticidal Dusts on Western Long Island, 1949[1]

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Tests in 1948 on Long Island indicated a marked decrease in the number of ears infested by the corn earworm, *Heliothis armigera* (Hbn.), following two to three applications of 5 per cent DDT dust (Butler and Carruth, 1949). This work was done by the use of hand-operated knapsack and rotary dusters. Definite but somewhat poorer control was obtained with similar applications of dusts containing 5 per cent dichlorodiphenyl dichloroethane and 1 per cent parathion. Preliminary work indicated the possibility that DDT residues on harvested husks might be reduced by using DDT in an impregnated form. The present paper reports continuation of these investigations on western Long Island during the season of 1949. Particular emphasis was placed on further tests of materials, equipment and application schedules.

MATERIALS.—All insecticides were used in dust form. The DDT dusts were of both mechanically-mixed and impregnated types. Mechanically-mixed DDT dusts were of 5 and 10 per cent strengths. Two types of 1.5 per cent impregnated DDT dusts were used: the first type was prepared by dissolving 1.5 pounds of technical grade DDT in 2 pounds of a solvent and spraying the resulting solution on 96.5 pounds of pyrophyllite while the latter was being agitated in a dust mixer. The second type was prepared from each of two commercial impregnated DDT dust concentrates both of which were subsequently diluted to form a finished dust containing 1.5 per cent DDT. One commercial concentrate was diluted with pyrophyllite, while for the other concentrate[5] a diluent prepared from ground to-

[1] New York State Agricultural Experiment Station Journal Paper No. 805 September 30, 1949.

[2] Resigned October 15, 1949.

Table 1.—Corn earworm control produced by various insecticide dusts applied with a hand bellows-type knapsack duster, and a rotary hand duster, western Long Island, 1949.

Dust Used	Knapsack Duster		Rotary Duster	
	Non-Infested Ears	Salable Ears	Non-Infested Ears	Salable Ears
	Per Cent	Per Cent	Per Cent	Per Cent
10% DDT	57.0	87.0	—	—
5% DDT	48.0	85.0	57.0	76.0
1.5% impregnated DDT[1]	56.0	91.0	69.5	84.5
1.5% impregnated DDT[2]	58.0	88.5	53.0	80.5
1.5% impregnated DDT[3]	38.5	78.5	43.5	71.5
1% parathion	25.5	75.0	41.5	61.0
5% DDD	32.0	70.5	46.5	70.5
Untreated	4.0	38.0	13.5	42.0
Sweet corn variety:	Magnagold		Seneca Giant	
Treatment dates:	Aug. 15, 17, 20, 23, 30		Aug. 6, 8, 10, 12, 17	
Harvest dates:	September 5		August 24	
Total number of ears examined:	200		200	
Number of replicates:	4		4	

[1] "Homemade" formulation.
[2] Prepared from impregnated 10% DDT concentrate.
[3] Prepared from an experimental impregnated 10% DDT concentrate furnished by Tobacco By-Products and Chemical Corporation. See text for further details concerning impregnated DDT formulations.

bacco stems was used. For comparison, dusts containing 1 per cent parathion[3] and 5 per cent dichlorodiphenyl dichloroethane were also used.

EQUIPMENT.—Knapsack and rotary hand dusters similar to those employed in 1948 were used. A high-clearance, self-propelled corn detasseler chassis upon which was mounted a row-crop duster was used for the larger scale tests. This equipment provided adequate clearance above the tallest sweet corn and nozzles were directed toward the silk region and adjusted to treat varieties of varying heights. The engine had four speeds and for adequate coverage of the silks it was found normally desirable to drive in second speed, estimated to be 3 to 4 miles per hour. The duster was operated with the outlet wide open, delivering about 50 pounds per acre of most of the materials.

In practically all cases, tests were randomized and replicated of rows from 150 to 250 feet long. Treatment replicates consisted of 1, 2, and 6 rows for knapsack, rotary, and tractor dusters, respectively. In the latter plots harvest data were taken from the two central rows only, although in all cases harvest records were based on a standard sample of 50 ears. Harvest records were expressed in terms of non-infested and salable ears. The non-infested ears were completely free from corn earworm infestation or injury. The salable ears included both the non-infested ears and an additional group classified as infested but salable in which earworm infestation and injury were confined to the silks and upper inch of the ears.

Relatively slight infestations of the fall armyworm, *Laphygma frugiperda* (A. & S.) and the European corn borer, *Pyrausta nubilalis* (Hbn.) produced but negligible injury to ears harvested from the test plots.

EXPERIMENTAL RESULTS.—To verify the results of 1948 tests of hand-operated equipment, similar comparisons using knapsack and rotary dusters were made during 1949. These results are summarized in table 1. Because heavy earworm infestations were indicated, five applications were made on the dates indicated in order to insure adequate coverage of each dust. In general, the two types of dusters produced comparable control. The difference between 5 per cent and 10 per cent mechanically-mixed DDT dusts was small. Comparable control was obtained with impregnated dust preparations containing 1.5 per cent DDT. The 5 per cent dichlorodiphenyl dichloroethane and 1 per cent parathion gave lower control.

Three tests in which dusts were applied with the six-row, self-propelled, high-clearance duster are summarized in table 2. Although three corn hybrids were used, earworm control was comparable. Uniformly satisfactory results were obtained with a 5 per cent DDT dust with no apparent advantage in control from the use of a 10 per cent DDT dust. A wider variation was noted between the different forms of impregnated DDT dusts, due possibly to unavoidable differences of rates of application. Further tests of these formulations are required at more accurately controlled application rates before valid comparisons are justified. Parathion and dichlorodiphenyl dichloroethane gave definite control, although neither was as effective as 5 per cent DDT.

Three tests in which 5 per cent DDT dust was applied with three types of equipment at different application schedules are summarized in table 3. In each case the first treatments were applied at the first time silks in a given planting first appeared. Various plots received from three to six dust applications at 2 and 3-day intervals, and no appreciable differ-

Table 2.—Corn earworm control produced by various insecticide dusts, each applied five times with a 6-row, self-propelled, high-clearance duster, western Long Island, 1949.

Dust Used	Test 1		Test 2		Test 3	
	Non-Infested Ears	Salable Ears	Non-Infested Ears	Salable Ears	Non-Infested Ears	Salable Ears
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
10% DDT	—	—	67.5	91.5	85.0	90.0
5% DDT	85.0	97.0	65.0	93.5	87.0	92.0
1 5% impregnated DDT[1]	75.0	89.5	—	—	—	—
1.5% impregnated DDT[2]	51.5	73.0	31.5	83.5	—	—
1.5% impregnated DDT[3]	32.5	56.5	—	—	—	—
1% parathion	71.0	89.0	48.5	86.5	63.0	79.0
5% DDD	50.0	75.0	39.5	83.0	—	—
Untreated	7.5	42.5	10.0	53.5	9.0	21.0
Sweet corn variety:	Seneca Giant		Magnagold		Golden Cross	
Treatment dates:	Aug. 6, 8, 10, 12, 17		Aug. 15, 17, 20, 23, 30		Aug. 12, 15, 17, 20, 23	
Harvest dates:	August 24		September 3		August 30	
Total no. ears examined:	200		200		150	
Number of replicates:	4		4		3	

[1,2,3] See corresponding footnote to Table 1.

ences were observed between the three types of equipment used, the number of applications or the intervals between applications.

It appears that adequate control of the corn earworm can be obtained with either hand or commercial equipment now available. Work in 1948 and in previous years indicated that a single application of DDT dust was insufficient for practical control. The present work indicates that a maximum of three properly made applications

Table 3.—Per cent corn earworm control produced by 5 per cent DDT dust applied at different schedules with three types of equipment in adjacent plantings, western Long Island, 1949.

Total No. of Applications	Dates Applied (August 1949)	Knapsack Duster		Rotary Duster		6-Row, Self-Propelled Duster	
		Non-Infested Ears	Salable Ears	Non-Infested Ears	Salable Ears	Non-Infested Ears	Salable Ears
3	7, 10, 15	59.5	86.0	—	—	—	—
3	8, 10, 12	—	—	—	—	83	88
3	9, 11, 15	64.5	95.0	—	—	—	—
3	10, 15, 19	74.5	83.0	—	—	—	—
3	11, 15, 17	79.5	86.0	—	—	—	—
4	6, 9, 12, 15	—	—	—	—	84	95
4	7, 9, 11, 15	76.0	94.5	61.5	90.0	—	—
4	7, 10, 15, 19	74.0	86.5	68.5	84.0	—	—
4	9, 11, 15, 17	81.5	86.0	74.0	88.0	—	—
5	6, 8, 10, 12, 14	—	—	—	—	86	94
5	6, 9, 12, 15, 18	—	—	—	—	79	90
5	7, 9, 11, 15, 17	81.5	91.0	—	—	—	—
5	7, 10, 15, 19, 22	83.0	88.0	—	—	—	—
6	6, 8, 10, 12, 14, 17	—	—	—	—	81	93
6	7, 9, 11, 15, 17, 19	87.5	93.5	—	—	—	—
Untreated: 1st series		19.5	58.0	(see columns to left)		6	41
2nd series		24.0	60.0				
Variety:		Magnagold				Seneca Giant	
Harvest Date:		August 25				August 24	
Number of replicates:		4				2	
Total ears examined per treatment:		200				100	

should be sufficient. The proper timing of applications on a given planting will probably vary according to the variety, seasonal conditions and other local factors. The guiding principle appears to be the keeping of the silks adequately covered with dusts during the period of oviposition and egg hatching.

During the 1949 season a number of growers on western Long Island purchased self-propelled six-row dusting outfits for corn earworm control. During the early part of the earworm season results obtained with these machines were unsatisfactory. Poor earworm control was found to be due to excessive operating speeds causing insufficient coverage of the silks. Later, when the machines were driven more slowly, good control was obtained.

DDT residue analyses were made of ear samples receiving various numbers of applications of mechanically-mixed and impregnated-type DDT dust formulations.

SUMMARY.—Insecticidal dusts containing DDT (in impregnated and mechanically mixed formulations), parathion and dichlorodiphenyl dichloroethane were tested against the corn earworm, *Heliothis armigera* (Hbn.), on western Long Island in 1949. Various treatment schedules were applied using hand-operated knapsack and rotary dusters in comparison with a motor operated row-crop duster mounted on a self-propelled, high-clearance, corn detasseler chassis. No appreciable differences in control were obtained between 5 per cent and 10 per cent mechanically-mixed DDT dusts. Good control was obtained with 1.5 per cent impregnated-type DDT dusts, although further tests of formulations are needed before such mixtures should be suggested for practical use. Adequate commercial control of the corn earworm was obtained with either hand or power operated equipment now available. Three carefully made dust applications, scheduled in accordance with local conditions, appeared sufficient.

LITERATURE CITED

Butler, G. D., Jr., and L. A. Carruth. 1949. Corn earworm control with DDT and other insecticides JOUR. ECON. ENT. 42(3): 457–61.

Control of Corn Earworm on Sweet Corn in Southern California[1]

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The oil injection method developed by Barber (1938) has been successfully used by some growers for control of the corn earworm, *Heliothis armigera* (Hbn.), in sweet corn in southern California (Wilcox 1943). However, this method requires exacting technique and is a slow and expensive operation. Ditman (1946) reports that the liquified-gas aerosol method is relatively ineffective on earworms on sweet corn. But Blanchard *et al.* (1946) have shown that atomization of oil mixtures with a paint spray gun gives promise of good control on field corn. In view of these findings, the following 12 experiments were conducted in the Coachella, Chino, and Riverside areas of southern California during the 1948 season, in an attempt to improve on the Barber (1938) oil-injection method.

INSECTICIDE APPLICATION METHODS.—*Oil-Can Injection.*—The insecticide injection method employed in these tests was the standard technique described by Barber (1938). A 1-pint force-oil can, with the trigger adjusted to deliver 0.5 to 0.6 cubic centimeters of insecticide per ear, was used for all injection tests.

High-Pressure Aerosol.—In these tests all aerosol applications were made with a

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high-pressure knapsack aerosol machine.[3] This aerosol machine was the same as that described by Stewart & Gammon (1948), except that a special trigger release valve was used to conserve insecticide while the operator was moving from ear to ear. The cylinder was charged with nitrogen gas to 500 pounds pressure per square inch, and the equipment was operated at 500 to 1000 pounds pressure per square inch. Although this equipment is capable of producing a very uniform, fine-particle-size aerosol, it was found to be more useful in earworm control when used as a high-pressure sprayer. By holding the nozzle close to the corn ears most of the insecticide was impinged on a relatively small area of the tip of the ear by the extreme force that exists for a few inches from the nozzle. When the nozzle is held 8 to 12 inches or more from the corn ear, the blast is low enough for the particles to become more or less dispersed and free-floating; therefore, they do not deposit so readily or penetrate the corn ear to so great an extent. The amount of insecticide applied by this equipment varied from 6 to 10 gallons per acre. In plots comparable in size, this method was found to be four to five times as rapid as the oil-can injection method.

Spray Gun (Atomization).—In Experiment 6 a paint-spray-gun equipment[4] was used. This equipment, which was mounted on a high-wheeled tractor, had six lead hoses, each one equipped with a paint spray gun. The hoses were arranged to extend back from a high boom, and there was thus one gun for each of six rows of corn. Each gun was operated by a man walking between the rows, treating the individual ears on one row only. In this particular experiment, the equipment operated at 20 to 30 pounds pressure, and the operators treated the ears from distances of about 2 and 10 inches. This spray-gun equipment, like the high-pressure aerosol equipment, used 6 to 10 gallons of insecticide per acre, but it sprayed more oil on the ear than the aerosol equipment. With the insecticides used, both methods impaired fertilization, and it was therefore necessary to time applications, as with the injection method, to avoid this.

Hand Spray.—In certain experiments insecticide spray was applied with a quart-sized, hand-pumped sprayer adjusted to thoroughly wet the tip of each ear of corn.

Dusting.—Insecticide dusts were applied by means of a small 1-quart plunger-type hand-puff duster or with a six-nozzle field power duster.[5]

INSECTICIDE FORMULATIONS.—In the 12 different experiments conducted for the control of the corn earworm in sweet corn during the 1948 season, the following insecticides were used: DDT, dichlorodiphenyldichloroethane, toxaphene, difluorodiphenyltrichloroethane, chlordan, methoxychlor, ditolyltrichloroethane, pyrethrum, styrene dibromide, parathion, and mineral oils.

The insecticide-mineral-oil mixtures used in the first eight experiments were prepared by dissolving the insecticide directly into the mineral oil. In all other tests, one part of insecticide was dissolved in two parts of xylene and then added to the mineral oil.

Unless otherwise stated, the oil used in these experiments was a refined mineral oil having a viscosity (Saybolt) of 185 to 195 seconds at 100° F.[6]

Insecticide emulsion mixtures were made by diluting commercially prepared 25 per cent concentrates to the desired percentages in water.

Insecticide dusts of DDT, dichlorodiphenyl dichloroethane, and parathion were diluted to the desired percentages in pyrophyllite.

PLOT ARRANGEMENT, SAMPLING TECHNIQUE, AND ANALYSIS OF DATA.—Plot arrangement and sampling techniques were varied to fit the particular experiment. In experiments 1, 2, and 4, the treatments and earworm sample records were non-replicated. In experiments 6, 10, and 11, the treatments were applied to large non-replicated blocks, but replicated earworm samples were taken for each treatment. In all other experiments, treatments were replicated and earworm samples were taken from each replicate. In experiments 1, 2, and 4, for each treatment, one hundred ears were examined for earworm damage. In all other experiments, 25 to 100 ears were examined for each replicate of each treatment, with a total of 100 to 300 ears per treatment. All data from experiments with replicated earworm-dam-

[3] The *Hi Fog* machine manufactured by the Banta and Driscoll Company.
[4] *De Vilbiss.*
[5] Manufactured by the Master Fan Corporation.
[6] No. 9 (100 per cent) USP oil; Standard Oil Company.

age records were analyzed by Fisher's methods for analysis of variance.

For experiments 7, 8, 9, and 11, corn ears examined for earworm damage were placed in four categories: (1) ears without worm damage, (2) slightly damaged ears in which worm injury was confined to the silk or tip of the ear, (3) moderately damaged ears in which worm injury extended 0.5 inch to 1.5 inches from the tip of the ear, and (4) severely damaged ears in which injury extended more than 1.5 inches from the tip of the ear. In these experiments, ears in categories 1 and 2 were considered marketable ears.

In experiment 12 many small worms were already present in the silk channels and on the tip of the ears when treatments were made, and as a result many dead worms were found in the treated ears. In this experiment corn ears were placed in three categories: (1) ears free of worms, (2) slightly injured ears having no worms or only dead worms present, and (3) ears containing live worms. Ears in categories 1 and 2 were considered marketable.

The data presented in this paper are in terms of marketable ears for experiments 7 and 12, and of worm-free ears for all other experiments.

OIL-INJECTION EXPERIMENTS 1, 2, AND 3, COACHELLA.—*Experiment 1.*—In this experiment seven different insecticide-treated lots of Golden Cross Bantam sweet corn and one untreated lot were compared (Table 1). Treatments were applied May 7 to corn ears in single-row, nonreplicated plots 200 feet long. All materials used were mineral-oil insecticide mixtures, applied by the oil-can injection

Table 1.—Control of the corn earworm by injection of mineral-oil insecticides into tips of ears of Golden Cross Bantam sweet corn—Experiments 1, 2, and 3, Coachella, California.

TREATMENT, INSECTICIDE IN MINERAL OIL[1]	WORM-FREE EARS PER 100		
	Experiment 1, 10 Days After Treatment	Experiment 2, 12 Days After Treatment	Experiment 3, 9 Days After Treatment
DDT			
1%	92	97	95
0.25%	—	—	91
Dichlorodiphenyl dichloroethane			
1%	—	98	95
0.25%	—	—	88
Chlordane			
1%	100	—	86
0.25%	—	—	82
Toxaphene			
1%	—	88	92
0.25%	—	—	81
Difluorodiphenyl trichloroethane			
1%	87	—	87
0.25%	—	—	83
Ditolyl trichloroethane			
1%	—	65	61
0.25%	—	—	77
Methoxychlor			
2%	88	—	82
1%	75	—	—
Mineral oil alone	73	54	78
Styrene dibromide, 2%	58	—	90
Check, untreated	4	6	25
Difference required for significance at 5% level	—	—	12

[1] For explanation of terms used, see section on "Insecticide formulations." Unless otherwise stated, the oil used in these experiments was a refined mineral oil having a viscosity (Saybolt) of 185 to 195 seconds at 100° F. (USP No. 9; Standard Oil Company).

method described above. Earworm infestation records were made on May 17, when 100 ears in each plot were examined.

Experiment 2.—On May 14, oil-injection experiments similar to those described in experiment 1 were made on Golden Cross Bantam sweet corn in single-row, nonreplicated plots 100 feet long. Five different mineral-oil insecticide mixtures were used. On May 26, one hundred ears in each plot were examined for earworms. Results are given in table 1.

Experiment 3.—In this experiment results of fifteen different oil-injection treatments were compared with those of no treatment on Golden Cross Bantam sweet corn (Table 1). Treatments were made May 24 on corn ears in single-row plots 50 feet long, replicated four times for each treatment. On June 2, earworm records were taken by examining 25 ears in each replication (a total of 100 ears for each treatment).

Results of Experiments 1, 2, and 3.—Data in table 1 show that in these experiments both 1 per cent DDT and 1 per cent dichlorodiphenyl dichloroethane gave good earworm control. The 1 per cent toxaphene, 1 per cent chlordan, 1 per cent difluorodiphenyl dichloroethane, and 2 per cent methoxychlor (except in one plot) appear to have been slightly less effective than the DDT and dichlorodiphenyl dichloroethane treatments. All these treatments resulted in 3 to 7 per cent more worm-free ears when used at 1 per cent concentration than when used at 0.25 per cent. Results with 1 per cent ditalyl trichloroethane, 1 per cent methoxychlor, and 2 per cent styrene dibromide (except in one plot) were no better than those with mineral oil alone, which were poor.

OIL-AEROSOL EXPERIMENTS 4 AND 5, AND OIL-ATOMIZATION EXPERIMENT 6, COACHELLA.—*Experiment 4.*—On May 14, oil-insecticide mixtures were applied by the high-pressure aerosol method described above to ears of Golden Cross Bantam sweet corn in single-row, 100-foot-long nonreplicated plots. On May 26, 100 ears from each plot were examined for earworms, and results of 10 treatments were compared with those of no treatment (Table 2).

Experiment 5.—In this test effects of eight different high-pressure aerosol treatments on ears of Golden Cross Bantam sweet corn were compared with effects of no treatment (Table 2). Insecticide applications were made May 25 on corn ears in single-row plots 50 feet long, replicated four times for each treatment. Earworm

Table 2.—Control of the corn earworm on Golden Cross Bantam sweet corn by applying oil insecticides by the aerosol method (Experiments 4 and 5) and by the atomization method (Experiment 6)—Coachella, California.

TREATMENT, INSECTICIDE IN MINERAL OIL[1]	WORM-FREE EARS PER 100		
	Experiment 4, 12 Days After Aerosol Treatment	Experiment 5, 8 Days After Aerosol Treatment	Experiment 6, 16 Days After Atomization With Paint Spray Gun
DDT in 3D oil[2]			
1%	—	—	69
4.5%	98	—	—
3D oil alone	94	—	75
DDT, 1%	97	88	79
Dichlorodiphenyl dichloroethane, 1%	95	96	71
Chlordane, 1%	92	92	74
Toxaphene, 1%	94	87	66
Methoxychlor, 2%	78	85	70
Difluorodiphenyl trichloroethane, 1%	82	81	78
Ditolyl trichloroethane, 1%	68	76	65
Pyrethrum, 0.2%	—	—	63
Mineral oil alone	70	77	75
Check, untreated	5	25	30
Difference required for significance at 5% level	—	9	12

[1] For explanation of terms and for description of oil used, see section on "Insecticide formulations" and footnote table 1.
[2] Shell Vapona 3D mineral oil; viscosity (Saybolt), 38.3 seconds at 100° F.; U. R., 92 per cent.

records were taken on June 2 by examining 25 ears in each replication (a total of 100 ears for each treatment).

Experiment 6.—On May 17 atomized oil-insecticide tests were made on ears of Golden Cross Bantam sweet corn, using the paint-spray-gun equipment described above. Results of 11 different treatments were compared with those of no treatment (Table 2). Six-row, nonreplicated plots averaging 150 feet long were used for each treatment. Earworm records were taken June 2 on 33 ears each from the second and fourth rows, and on 34 ears from the sixth row, of each plot (a total of 100 ears for each treatment).

Results of Experiments 4, 5, and 6.—The results of these experiments (Table 2) show that DDT, dichlorodiphenyl dichloroethane, toxaphene, and chlordan at 1 per cent concentration in mineral oil, applied by the high-pressure aerosol method (experiments 4 and 5), all gave good control of the earworm (87 to 97 per cent wormfree ears). Control with these materials when applied by the aerosol method was thus as good as when applied by the injection method (86 to 100 per cent worm-free ears), as shown in table 1. Results from applications of 2 per cent methoxychlor, 1 per cent difluorodiphenyl trichloroethane, 1 per cent ditotyl dichloroethane, and mineral oil alone as aerosols were about equal (68 to 85 per cent worm-free ears), whereas the untreated checks showed only 5 to 25 per cent worm-free ears. The 3D mineral oil (Table 2), used in some of the tests with and without DDT, gave excellent control of the earworms, but it burned the shucks, silk, and tips of the ears.

In the atomization test (experiment 6), the addition of insecticides to the mineral oil did not significantly increase the earworm control over that of mineral oil alone. However, the results of the different treatments ranged from 63 to 79 per cent worm-free ears, and these were significantly better than results for the untreated ears, which were 30 per cent clean. The atomization method was not so effective as the high-pressure aerosol method.

INJECTION EXPERIMENT 7 AND AEROSOL AND SPRAY EXPERIMENT 8, RIVERSIDE.—*Experiment 7.*—In this experiment nine insecticide injection treatments (Table 3) were compared with no treatment for the control of corn earworm on sweet corn. Injections were made on July 17 on corn ears in plots two rows wide and 30 feet long, replicated five times for each treatment. Each replicate was on a different variety

Table 3.—Comparative results in control of the corn earworm on Golden Cross Bantam sweet corn with insecticides applied by the injection method (Experiment 7) and by aerosol and spray methods (Experiment 8)—Riverside, California.

TREATMENT[1]	MARKETABLE EARS PER 100 13 DAYS AFTER INJECTION TREATMENT	WORM-FREE EARS PER 100 13 DAYS AFTER TREATMENT	
		Aerosol Treatment	Spray Treatment
DDT			
1% in mineral oil	96	95	—
0.5% in mineral oil	87	—	—
0.25% in mineral oil	89	—	—
1% emulsion	83	38	26
Dichlorodiphenyl dichloroethane			
1% in mineral oil	88	94	45
0.5% in mineral oil	87	—	—
1% emulsion	73	25	—
Mineral oil alone	67	58	7
Pyrethrum, 0.2% in mineral oil	68	—	—
Parathion, 25% wettable powder (2 lb./100 gal.)	—	—	0
Check, untreated	44	2	2
Difference required for significance at 5% level	13	14	14

[1] For explanation of terms and for description of oil used, see section on "Insecticide formulations" and footnote table 1.

of sweet corn, namely, two strains of Golden Cross Bantam, Ioana D. R., Golden Pride, and Jerseyana. On July 30, 25 ears were examined on each plot, or a total of 125 ears for each treatment. Owing to variability of the varieties Golden Pride and Jerseyana, the counts for these varieties are not included in the results given.

Experiment 8.—Insecticide aerosol and spray treatments were made on July 16, results of nine treatments being compared with no treatment on Golden Cross Bantam sweet corn (Table 3). The aerosol and spray methods used were those described above. The plot size and arrangement was the same as for experiment 7, except that one variety of corn was used for all replications. On July 29, 25 ears were examined in each plot (a total of 125 ears for each treatment). Results are summarized in table 3.

Results of Experiments 7 and 8.—It is evident from the results given in table 3 that there is little difference in earworm control between the 1 per cent DDT and 1 per cent dichlorodiphenyl dichloroethane oil-aerosol treatments and the 0.25, 0.5, and 1 per cent DDT and 0.5 and 1 per cent dichlorodiphenyl dichloroethane oil-injection treatments, all producing 87 to 96 per cent clean ears. However, injected and aerosoled 1 per cent DDT and 1 per cent dichlorodiphenyl dichloroethane emulsions were significantly poorer than injected and aerosoled 1 per cent DDT and 1 per cent dichlorodiphenyl dichloroethane mineral-oil mixtures. Also, the injected 0.2 per cent pyrethrum-mineral oil and the injected and aerosoled mineral oil alone (68, 67, and 58 per cent clean ears, respectively) were significantly poorer than the injected and aerosoled DDT and dichlorodiphenyl dichloroethane oil mixtures. One per cent dichlorodiphenyl dichloroethane-oil, 1 per cent DDT-emulsion, and mineral oil alone gave significantly poorer control as sprays than they did as aerosols. Spray containing 25 per cent parathion as wettable powder gave no control of earworms.

DUSTING EXPERIMENT 9, RIVERSIDE.—In this experiment treatments with 10 per cent DDT, 10 per cent dichlorodiphenyl dichloroethane, and 0.5, 1, and 2 per cent parathion dusts were compared with checks for control of earworm on sweet corn (Table 4). Treatments were made on July 16 on corn ears in two-row plots 34 feet long, replicated five times for each treatment. Each replication was on a different variety of sweet corn, as follows: Ioana D. R., Golden Grain, Marketwise, Golden Rush, and Aristogold Bantam No. 2. Fifty ears were examined from each replicate of each treatment, but owing to the variability of the varieties Ioana D. R., and Golden Rush, only the data from the other three varieties are presented (Table 4). For this test, a small 1-quart plunger-type hand-puff duster was used, and the silks and tips of all treated ears were dusted individually and given a heavy deposit of material. The corn was harvested and worm counts were made July 26 to August 2. In this experiment all dust treatments resulted in very few worm-free ears (24 per cent or less), with the parathion showing the poorest results. The poor control with these dusts was probably due to the inadequate number of applications.

Table 4.—Control of the corn earworm with dust insecticides applied by means of a hand-puff duster to tips of ears of sweet corn varieties Golden Grain, Marketwise, and Aristogold Bantam No. 2—Experiment 9, Riverside, California.

DUST TREATMENT (WITH PYROPHYLLITE AS DILUENT)	POUNDS PER ACRE	WORM-FREE EARS PER 100
DDT, 10%	12	22
Dichlorodiphenyl dichloroethane, 10%	12	24
Parathion		
0.5%	16	17
1%	24	11
2%	24	8
Check, untreated	—	6
Difference required for significance at 5% level	—	12

DUSTING EXPERIMENT 10, COACHELLA.—In this test treatments with 10 per cent DDT dust and with 5 per cent dichlorodiphenyl dichloroethane dust were compared with checks for control of earworm on Golden Cross Bantam sweet corn. Each dust was applied to non-replicated plots of corn 18 rows wide and 250 feet long. Treatments were made with a 6-nozzle power field duster, using one nozzle per row. Applications were made on May 11, 15, 20, and 25. The first application was made before the silks had appeared, and the last application was made 7 days before harvest.

All applications were at the rate of 40 pounds of dust per acre, except the first DDT treatment, which was at the rate of 100 pounds per acre. On June 2, 300 ears were examined in each treated area and in an untreated area, and worm-free ears were found, as follows: DDT-treated, 72 per cent; dichlorodiphenyl dichloroethane treated, 38 per cent; and untreated, 25 per cent.

INJECTION AND AEROSOL EXPERIMENT 11, CHINO.—In this experiment injection and aerosol applications of 1 per cent DDT or dichlorodiphenyl dichloroethane mineral oil solutions and 5 per cent DDT emulsion were compared with checks for earworm control on Golden Cross Bantam sweet corn (Table 5). In the aerosol treatments comparisons were made of the effect of varying the distance between the nozzle and the tip of the ear. The treatments were applied on August 18 to non-replicated four-row plots 360 feet long. Earworm records were taken on August 27 by examining 50 ears in each row (200 ears for each treatment). The methods of injection and aerosol applications were the same as those described above, except in four of the aerosol treatments. For these four treatments, a 3-foot boom pipe was inserted between the shut-off valve and the nozzle. The pipe was adjusted to ride over the shoulder of the operator, with the nozzle directed to the rear at an angle of about 45 degrees with the row of corn, and at corn-ear level. For one treatment a single nozzle was used, and the operator treated only one side of one row at a time. For the other three treatments, a "Y" attachment was placed on the end of the boom pipe and two nozzles were used. Thus, as the operator walked down each alley between rows he was able to treat one side of each of two rows.

The results of experiment 11 (Table 5) show that the injection treatment with 1 per cent DDT in oil was significantly better than the aerosol treatment with 1 per cent dichlorodiphenyl dichloroethane in oil, and almost significantly better, statistically, than the aerosol treatment with 1 per cent DDT in oil. The 1 per cent DDT-oil aerosol treatment applied with the nozzle held about 2 inches from the tip of the ears was significantly better than the same treatment with the nozzle held about 10 inches from the tip of the ears. At the 2-inch distance, the 5 per cent DDT-emulsion aerosol was only about half as effective as the 1 per cent DDT-oil aerosol. The 1 per cent DDT-oil aerosol treatments using the long boom pipe over the operator's shoulder were significantly poorer than the same treatment when using the trigger-gun nozzle in front of the operator. The 5 per cent

Table 5.—Results of injection and aerosol tests for control of the corn earworm on Golden Cross Bantam sweet corn—Experiment 11, Chino, California.

TREATMENT[1]	APPLICATION		WORM-FREE EARS PER 100, 9 DAYS AFTER TREATMENT
	Method[2]	Distance of Nozzle from Tip of Corn Ear, Inches	
DDT, 1% in mineral oil	Injection	—	86
DDT, 1% in mineral oil	Aerosol	2	79
Dichlorodiphenyl dichloroethane 1% in mineral oil	Aerosol	2	75
DDT, 1% in mineral oil	Aerosol	10	42
DDT, 5% emulsion	Aerosol	2	36
DDT, 1% in mineral oil	Aerosol-LB	10	30
DDT, 1% in mineral oil	Aerosol-YB	10	28
DDT, 1% in mineral oil[3]	Aerosol-YB	10	24
DDT, 5% emulsion	Aerosol-YB	10	10
Check, untreated	—	—	16
Difference for significance at 5% level			8

[1] For explanation of terms and for description of oil used, see section on "Insecticide formulations" and footnote table 1.
[2] LB = long, single-nozzle boom pipe operated over shoulder and covering one corn row at a time; YB = similar boom pipe fitted with a Y-shaped tip with two nozzles and adjusted to cover two corn rows at a time.
[3] Socony Vacuum No. 2 mineral oil; viscosity (Saybolt), 100 to 105 seconds at 100° F.; U.R., 90 per cent.

DDT-emulsion aerosol treatment using the boom over the operator's shoulder gave no earworm control.

Commercial applications of aerosols were made on Golden Cross Bantam sweet corn at Chino on September 4. In these tests the effect of 1 per cent dichlorodiphenyl dichloroethane mixed with a mineral oil having a viscosity (Saybolt) of 75 to 85 seconds at 100° F.[7] was compared with that of 1 per cent dichlorodiphenyl dichloroethane mixed with a mineral oil having a viscosity (Saybolt) of 145 to 155 seconds at 100° F.[8] Earworm counts made 5 days after treatment showed approximately 80 per cent reduction in live worms in both treatments, in comparison with nontreated ears.

OIL-INJECTION AND AEROSOL EXPERIMENT 12, COACHELLA.—In this experiment injection and aerosol treatments with dichlorodiphenyl dichloroethane and DDT in oil, and with mineral oil alone, were compared with no treatment for earworm control on sweet corn (Table 6). The treatments were applied on November 1 to single-row plots 50 feet long, replicated five times for each treatment. The corn was harvested on November 12 and examined for earworm infestation.

This insecticide experiment was superimposed on a sweet-corn variety trial in which the following 13 varieties or types of corn were grown: 9 of Golden Cross Bantam, 2 of Ioana, 1 of Flagship, and 1 of Seneca Chief. The insecticide-treated plots were selected at random, irrespective of variety plots, and in only four instances did any one treatment occur twice on the same variety of sweet corn. All of these varieties mature about the same time, but the average infestation of ears by the corn earworm in the two untreated plots of each variety ranged from 65 to 92 per cent. In spite of the variability introduced by the varietal influence on the earworm population, significant differences were obtained between insecticide treatments.

Results (Table 6) show that the effects of 1 per cent DDT in oil and 1 per cent dichlorodiphenyl dichloroethane in oil, when applied by the best aerosol and injection methods, were about equal, with 87 to 90 per cent marketable ears. DDT-oil and dichlorodiphenyl dichloroethane-oil aerosol applications with the nozzle held 2 inches from the tip of the corn ear were slightly more effective than those with the nozzle held against the ear, which, in turn, were slightly more effective than those with the nozzle held 10 inches from the ear. Oil alone, applied by injection or aerosol methods, resulted

[7] No. 3 (100 per cent) USP oil; Standard Oil Company.
[8] No. 7 (100 per cent) USP oil; Standard Oil Company.

Table 6.—Results of injection and aerosol tests for control of the corn earworm on several varieties of sweet corn—Experiment 12, Coachella, California.

TREATMENT[1]	APPLICATION		MARKETABLE EARS PER 100
	Method	Distance of Nozzle from Tip of Corn Ear, Inches	
Dichlorodiphenyl dichloroethane 1% in mineral oil	Injection	—	90
DDT, 1% in mineral oil	Injection	—	88
DDT, 1% in mineral oil	Aerosol	2	88
1% in mineral oil	Aerosol	2	87
1% in mineral oil	Aerosol	0	84
Dichlorodiphenyl dichloroethane 1% in mineral oil	Aerosol	0	83
DDT, 1% in mineral oil	Aerosol	10	75
Dichlorodiphenyl dichloroethane 1% in mineral oil	Aerosol	10	72
Mineral oil alone[2]	Aerosol	2	70
Mineral oil alone[2]	Injection	—	68
Average, 6 checks (untreated)	—	—	18
Difference required for significance at 5% level			12

[1] For explanation of terms and for description of oil used, see section on "Insecticide formulations" and footnote table 1.
[2] Viscosity (Saybolt), 75 to 90 seconds at 100° F.; Union Oil Co.

in 68 to 70 per cent marketable ears, as compared with 87 to 90 per cent marketable ears when DDT or dichlorodiphenyl dichloroethane was added to the oil.

INSECTICIDE RESIDUE ANALYSIS.—In experiments 2, 3, and 5, samples of corn ears were taken for DDT residue analyses from the 1 per cent DDT-mineral oil injection- and aerosol-treated plots. Analyses by the dehydrohalogenation method showed 3–5, 20–35, and 0 p.p.m. DDT on the husk and silk, tip of the ear, and kernels, respectively, for injected ears; while 18–51, 54–137, and 0 p.p.m. DDT were found, on aerosol treated ears.

SUMMARY.—During the 1948 season, 12 experiments were conducted in the Coachella, Chino, and Riverside areas of southern California for the control of the corn earworm, *Heliothis armigera* (Hbn.), on sweet corn. In these experiments the results of 115 insecticide treatments on sweet corn in 404 plots were compared.

The insecticides used in these experiments were the following: DDT, dichlorodiphenyldichloroethane, toxaphene, difluorodiphenyltrichloroethane, chlordane, methoxychlor, ditolyltrichloroethane, pyrethrum, styrene dibromide, parathion, and mineral oils. They were applied as dusts, by hand machines and power dusters; as sprays, by hand sprayers; as aerosols, by a new high-pressure knapsack aerosol machine; and as solutions, by an oil-can injection method.

In the tests it was found that 1 per cent DDT and 1 per cent dichlorodiphenyl dichloroethane in mineral oil gave the best control of the earworm, and that they were most effective when applied by either the aerosol or the injection method. Dust applications were found to be ineffective, but the poor control obtained in these experiments was probably due to the inadequate number of applications. Sprays gave some control but were inferior to aerosol applications. Water emulsions were inferior to oil solutions.

Tests with the aerosol machine were made by varying the distance between the nozzle and the tip of the corn ear, and a 2-inch distance was found to be the most effective. The injection method was slightly more effective than the aerosol method of application, but the aerosol method was four to five times as rapid. The amount of material used by the aerosol method ranged from 6 to 10 gallons per acre. Applications by either the aerosol or the injection method should not be made until after the sweet corn is pollinated.

In these tests no DDT residues were found on the edible portion of the ear of corn, but from 3 to 137 p.p.m. were found on the husk, silk, or tip of the ear.

LITERATURE CITED

Barber, G. W. 1938. New control methods for the corn ear worm. JOUR. ECON. ENT. 31(3): 459.

Blanchard, R. A., T. R. Chamberlin, and A. F. Satterthwait. 1946. Controlling the fall armyworm in sweet corn and popcorn with DDT. JOUR. ECON. ENT. 39(6): 817.

Ditman, L. P. 1946. DDT aerosols to control worms in corn. JOUR. ECON. ENT. 39(5): 668.

Stewart, Wm. S., and Cyril Gammon. 1948. A back-pack fog gun for 2,4-D application. JOUR. ECON. ENT. 41(4): 658.

Wilcox, J. 1943. Practical field tests of oils and oils containing other insecticides for the control of the earworm in southern California. JOUR. ECON. ENT. 36(4): 554–7.

NEW JOURNAL OF TROPICAL MEDICINE

A new quarterly journal of tropical medicine and hygiene entitled "Documenta Neerlandica et Indonesica de Morbis Tropicis" has recently appeared. It is entirely in English, although published in Amsterdam. (Rivierenloan 268, subscription price $4.50 per annum.)

The editorial board is staffed by a group of widly known scientists under the chairmanship of Prof. N. H. Swellengrebel. The journal is well printed on good paper and the numerous illustrations are excellent. The articles in the first two numbers cover a wide range of subjects including scrub typhus, malaria and some entomology.—F. C. B.

Seed Treatments for Wireworm Control with Particular Reference to the Use of Lindane[1]

W. H. Lange, Jr., E. C. Carlson, and L. D. Leach,[2] *University of California, Davis*

Soil treatments using fumigants or other residual chemicals, such as DDT, benzene hexachloride, and chlordan, have proved effective in controlling wireworms, but in some cases they are expensive or may build up large amounts of chemicals in the soil. In addition, they may affect plant growth, may be translocated into plants or, in certain instances, may cause objectionable flavors and other detrimental effects to fruits and vegetables.

Seed treatment cannot supplant the use of these residual materials as soil treatments if control is based upon reduction in total wireworm populations. Under California conditions, however, seed treatment has been an effective and practical means of wireworm control when the seeds of a specific crop are not injured by an effective dosage of a chemical, and when wireworms in sufficient numbers are attracted to the seed zone during germination.

The coating or impregnation of seeds with substances that repel or poison wireworms is a method of wireworm control which has received considerable attention by previous workers. Thomas (1940) points out, however, that none of the materials used has been entirely satisfactory.

Benzene hexachloride as a seed treatment for the control of wireworms was reported by Lange (1947) in California, where 2 per cent of a technical grade material (10 to 12 per cent gamma isomer content) was used to treat sugar beet seed. Lange *et al.* (1949) presented a progress report on the use of high gamma benzene hexachloride for the control of wireworms on baby lima beans, suggesting a dosage of 4 ounces of a 25 per cent gamma material to 100 pounds of beans. Hocking (1949) mentioned the control of wireworms affecting wheat by means of seed treatment but reported that to avoid plant injury, only the pure gamma formulations of benzene hexachloride should be used.

Dogger & Lilly (1949) found parathion applied to corn seed to be highly toxic to *Melanotus communis* (Gyll.), *Dalopius pallidus* Brown, and certain other wireworms, when the chemical was used at the rate of 4 and 8 ounces of 50 per cent dust per bushel. They found that gamma benzene hexachloride gave some protection under field conditions but that chlordan proved ineffective.

The adverse effects of benzene hexachloride on seeds and on growing plants have been reported by several workers. McLeod (1946, 1946a), in connection with the control of the onion maggot, mentioned damage to onions from coating the seeds and treating the soil. Brooks & Anderson (1947), using a 0.5 per cent gamma benzene hexachloride applied at the rate of 12 pounds per bushel to two varieties each of sweet corn, snap beans, and lima beans, obtained a reduction in germination of all except Black Valentine snap beans and Aristagold sweet corn. Methocel was used to stick the chemical to the seeds. Stoker (1948) applied benzene hexachloride to seedling vegetables and obtained considerable phytotoxicity. Morrison, *et al.* (1948) have studied the effects of soil treatments of benzene hexachloride and other chemicals on plant growth and report injury in certain instances. More recently, Kostoff (1948, 1949) has found that benzene hexachloride is capable of causing cytogenetic changes in addition to atypical growth of certain plants.

That the adverse effect of crude benzene hexachloride on wheat seedlings is not due to the gamma isomer is suggested by Hocking (1949). This author states that a mixture of trichlorobenzenes (formed by the alkaline breakdown of alpha benzene hexachloride) possesses the ability to inhibit germination and suggests that it could be 1, 3, 5-trichlorobenzene, possibly another trichlorobenzene, or another volatile breakdown product of benzene hexachloride.

Tests conducted in the greenhouse during 1946 showed that technical grades of benzene hexachloride, containing 10 to 12 per cent gamma isomer and a mixture of other isomers, were very toxic to wire-

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worms when used as seed treatments. Upon some crops, such as sugar beets, dosages as high as one or two per cent of the seed weight appeared non-injurious while similar dosages upon other crop seeds caused serious seedling injury or even prevented emergence.

The first effective field control of wireworms in California by means of seed treatment was obtained in 1947. Several hundred pounds of processed sugar beet seed was treated with 2 per cent of technical grade benzene hexachloride applied as a dry powder. During 1947, the phytotoxicity of the technical grades of benzene hexachloride to most seeds restricted its use chiefly to sugar beets, which are fairly tolerant to it. The dosage was lowered to approximately one per cent of the weight of the seed.

In 1948, formulations prepared from 99.95 per cent gamma isomer, now called lindane, appeared on the market. The fact that most crops tested were found tolerant to these preparations made it possible to expand the seed treatment program. Investigations were started to determine the maximum amounts of this chemical different seeds would tolerate, and the minimum amount necessary to give adequate wireworm protection. As the use of a fungicide seed treatment is a standard practice, it was necessary to study the compatibility of benzene hexachloride and other chemicals with fungicides.

These investigations indicated that, in order to be effective as a seed treatment, a chemical must seriously affect or kill wireworms within a short time. Because of its quick action in this respect, benzene hexachloride has proved to be one of the most promising chemicals for seed treatment.

During 1948 and 1949, wireworm control by seed treatment has been used with satisfactory results on thousands of acres of sugar beets and baby lima beans, and on limited acreages of other beans, sweet corn, milo, cucumbers, field planted tomatoes, spinach, and barley.

FACTORS DETERMINING EFFICACY OF SEED TREATMENTS.—The efficacy of seed treatments depends upon a number of criteria including among others the species of wireworms involved, wireworm activity at the time the seed is planted, the proportion of the population attracted to the seed, the type of seed, and the time of planting. That the several species of wireworms differed in susceptibility to benzene hexachloride was first noticed in the field when milo seed treated with this chemical failed to kill an *Anchastus* sp. Various species tested in the laboratory also reacted differently. Because it is more active, results were easier to determine on *Limonius canus* Lec. than on *L. californicus* (Mann.) and *L. clypeatus* Mots. Two other wireworms, *Melanotus oregonensis* (Lec.) and an *Aeolus* sp., were readily affected.

In order to determine possible further differences in susceptibility to benzene hexachloride, a preliminary experiment was conducted. Four species of wireworms were confined separately in 4-ounce salve cans filled with soil, treated May 10, 1948, with one pound per acre of gamma isomer, as lindane, mixed with the upper 5 inches of Yolo clay loam soil. The soil sample was taken September 13, 1948; worms were introduced November 6, 1948. The results summarized in table 1 indicate that *Aeolus* sp. was the most susceptible to benzene hexachloride, followed by *Limonius canus*, *L. californicus*, and finally *Anchastus* sp., which was the least susceptible.

Ordinarily only 50 to 70 per cent of the population of larger wireworms are attracted to the seed at the time of germination; usually 70 to 95 per cent of these are killed. However, the control of this proportion of the wireworms allows a stand to become established. With certain crops, such as sugar beets and lima beans, wireworms coming up later may do some feeding on the small plants without seriously reducing the stands.

Effectiveness of seed treatments depends upon the attraction to wireworms of the particular type of seed planted as well as upon the presence in some cases of old seed parts in the soil. For example, the old parts of spinach seed treated with benzene hexachloride remain effective in killing wireworms four months after planting, and treated sugar beet seed balls remain effective for several months. The wireworms apparently come in contact with the old seed balls in their movements through the soil. The amount of seed planted per acre may also influence the results.

Seed of certain cold weather crops, such as spinach or sugar beets, can be planted

Table 1.—Mortality at time intervals of several species of wireworms in soil treated with lindane at the rate of one pound of gamma isomer per acre, as determined in salve cans in the laboratory.[1]

	Per Cent Mortality					
	4 weeks		8 weeks		16 weeks	
Species of Wireworm	Moribund	Dead	Moribund	Dead	Moribund	Dead
Anchastus sp.	9.1	0.0	18.2	0.0	36.4	27.3
Check	0.0	0.0	0.0	0.0	0.0	0.0
Limonius californicus	50.0	0.0	75.0	0.0	66.7	33.3
Check	0.0	0.0	0.0	0.0	0.0	16.7
Limonius canus	66.7	0.0	66.7	0.0	16.7	66.7
Check	0.0	0.0	0.0	0.0	0.0	0.0
Aeolus sp.	83.3	0.0	83.3	16.7	50.0	50.0
Check	0.0	0.0	0.0	0.0	0.0	0.0

[1] Soil (Yolo clay loam) collected in the field on September 13, 1948 and stored dry until used on November 6, 1948. Speed of insecticidal action and total mortalities were lower in this case than would be expected from a fresh soil treatment, as 180 days elapsed between soil treatment and worm introduction.

in the fall or winter when wireworms are not active. In that case, some damage to young seedlings may occur when the wireworms move to the surface again in the spring. By this time, the amount of actual insecticide remaining on the seed coats in the soil is very much reduced. Seed treatments may not provide sufficient protection then for cold weather crops.

The present investigations have been directed along the following lines: (1) tolerance of different seeds to chemical treatments; (2) toxicity of treatments to wireworms in the laboratory and field; (3) the efficacy of insecticide-fungicide combinations, involving their efficiency and compatibility; and (4) field trials to check effect of treatments on final yields, degree of plant injury, and reduction in wireworm populations.

Methods.—Insecticides or fungicides for laboratory or field trials were applied to seeds in several ways: (1) a measured dosage of chemical in dust form was applied in open, rotating mixers; (2) other seed was given the same dry treatment and then was lightly sprayed with water to make the chemical stick (liquid fixation); (3) liquid treatments, as suspensions of wettable powders or as solutions, were applied by means of a sprayer; and (4) still other seed was treated with a liquid suspension by means of a slurry seed treater (slurry treatment).

In laboratory work, 200 to 500 grams of seeds were treated in a specially designed seed treater. Usually the chemicals were applied as suspensions of wettable powders and were sprayed on the rotating seed by means of a DeVilbiss atomizer. The distribution of the chemical could be checked by the addition of a dye. In field treatments a cement mixer was used, and the solutions or suspensions were sprayed on by means of a compressed air sprayer, or the seed was treated in a slurry machine. The amount of moisture added to different seeds was varied, since smooth-coated seeds, such as beans, would take the addition of only one-quarter to one-half per cent moisture (of total weight of seed), whereas such rough-coated seeds as sugar beets would take up to 4 per cent moisture.

In the greenhouse, pasteurized soil was used to test the effect of the chemicals upon emergence, rate of emergence, and growth, this last factor being measured by average seedling weights. Usually six single row replications of treatments were planted, in either pasteurized or pathogen infested soil. Rate of emergence was determined as the mean emergence period by the method used by Leach & Smith (1945). The protective effects of the chemicals with infested soils was measured by differences in emergence or by seedling infection.

Under field conditions, the insecticidal or fungicidal value of treatments was determined also by stand counts, growth observations, and yields.

It was found that a satisfactory index of the relative insecticidal value of a particular seed treatment could be determined in the laboratory. Varying numbers of seeds, usually 2 to 6, depending upon the size, were buried in air-dried soil in 4 ounce metal salve cans. A uniform amount of distilled water was added on the surface, and 2 wireworms were placed in each can. Six replications of each treatment were used; the cans were kept at a uniform temperature of 54° F. for later observation. Counts of affected, moribund, and dead worms were made within 1 or 2 weeks and at 2 week intervals up to 12 weeks, depending upon the rate of kill. For comparisons within a single test, it was necessary to use wireworms of similar size from a single species. These were field collected from one locality and were stored and handled uniformly.

LABORATORY OR GREENHOUSE RESULTS.—*Tolerance of Different Seeds.*—The tolerances to benzene hexachloride and certain other chemicals were determined. It was soon apparent that seed differed widely in their ability to withstand seed treatments. Most of the early tolerance work was carried out with technical grade benzene hexachloride formulations,[1] while later tests made use of high gamma formulations,[2] which have less phytotoxicity. The availability of slurry seed treaters, together with the fact that by this method such a small amount of moisture is applied to seed, led to the development of a 75 per cent gamma content benzene hexachloride from lindane. The more recent tolerance tests have included the use of this high gamma formulation.

The tolerance of different seeds to fungicides with and without insecticides has also been determined in part, as fungicides are commonly applied to seeds to control certain seed-borne and soil-borne pathogens. During this study, the effects of these chemicals were studied on the following crops: sugar beets, beans, milo, barley, corn, cucumbers, cantaloupe, tomato, okra, lettuce, peas, cotton and wheat.

Sugar Beets.—The earlier tests in 1946 and 1947, using technical forms of benzene hexachloride (10 per cent gamma isomer), at 1 per cent by weight, indicated occasional emergence delay or failure to emerge and decreased seedling weights. In a greenhouse test conducted on July 30, 1946, benzene hexachloride and DDT at 1 per cent strength had no protective value against *Pythium ultimum*, but did not reduce the protective value of 1 per cent phygon. When a technical grade benzene hexachloride formulation was substituted, it was determined that not over 0.5 per cent by weight of seed could be used without injury. A lindane formulation containing 25 per cent gamma isomer, and used at the rate of 1 per cent of the weight of seed, could be applied as wet or dry treatments with no decrease in emergence or increase in the mean emergence period. In one trial even 2 per cent appeared non-injurious, but in another trial 2.5 per cent caused a delay and a reduction in germination.

Chlordane as a seed treatment, using 1 and 2 per cent by weight of a 47 per cent emulsifiable mixture with an oil base, delayed germination, but 2 per cent of a 50 per cent wettable powder had no significant effect on germination or rate of emergence. Sugar beet seed, treated with 1 and 2 per cent by weight of 25 per cent lindane and stored 10 months in quart glass jars with loosely fitting lids, lost approximately half of its insecticidal efficiency to wireworms when checked under laboratory conditions. Seed stored for 15 months under similar conditions and planted in pasteurized soil in the greenhouse caused a delay of 2 to 3 days in emergence and resulted in only 60 per cent emergence as compared with untreated seed.

In greenhouse trials with beets, there was evidence that benzene hexachloride had some fungicidal effect on *Phoma betae* but none upon *Pythium ultimum*.

Baby Lima Beans.—Inasmuch as the tolerance of baby lima beans to benzene hexachloride and other chemicals differs from that of the larger varieties, the two types will be discussed separately.

Tests on Henderson bush lima beans August 5 and 12, 1946, indicated that

[1] The technical grade benzene hexachloride used in these trials was micronized and contained 10 per cent gamma isomer and 24 per cent other isomers. (Pa. Salt Co.)

[2] The high gamma or lindane preparations used were furnished by California Spray Chemical Corp. and consisted of two formulations: 1) a 25 per cent gamma content wettable powder, "*Isotox*"; and 2) a 75 per cent formulation known as "*Seed Treater.*"

neither DDT nor Spergon delayed or reduced emergence in sterile soil, but that technical benzene hexachloride (of 10 per cent gamma isomer content) at a dosage of 1 per cent delayed and reduced emergence. Benzene hexachloride exhibited no fungicidal properties in this particular experiment. In the 1947 and 1948 experiments where technical benzene hexachloride was used, baby lima beans exhibited reduced emergence, delayed emergence, stunting of the plants, and decreased seedling weights. In most tests it was necessary to reduce the dosage to 0.125 per cent to escape injury.

A safe dosage to Wilbur baby lima beans was found to be 0.25 per cent by weight of 25 per cent gamma formulations from lindane, applied as either a wet or dry treatment. Although occasional reduction and delay in germination occurred, no injury was obtained at the 0.125 per cent dosage by weight.

Large Lima Beans.—The effects of a 75 per cent gamma formulation from lindane on two varieties of large lima beans was studied during May, 1949 and are summarized in table 2. Two concentrations were used, 0.66 ounce and 1.33 ounces per 100 pounds of beans. It was apparent that the Fordhook Concentrated Bush Lima bean was more susceptible to lindane than the Ventura Lima. With Fordhook beans, the lower dosage resulted in a significant delay in germination, while the higher dosage caused an additional delay and resulted in a reduced final emergence. This is shown in figure 1, D. There was also some evidence that lindane directly affects either the growth of the plants or the absorption of the cotyledons, as is indicated by the differences in cotyledon weights. Differences in rates of cotyledon absorption due to chemical injury by certain fungicides were demonstrated in peas by Leach & Smith (1945). With Ventura limas, the lower dosage had no significant effect on emergence or seedling weight, although the higher dosage reduced seedling weight and gave a temporary delay in germination. The emergence data are portrayed in figure 1, C.

During June, 1949, tests were conducted with Fordhook Concentrated Bush Lima beans using as slurry treatments aldrin and dieldrin at the rate of 2 ounces of 25 per cent wettable powder, and chlordan at 2 ounces of 40 per cent wettable powder. Aldrin[1] and dieldrin[2] effected a reduction in seedling weight while chlordane showed none. The two compounds also caused a slight delay in emergence when expressed as the mean emergence period, whereas chlordane again had no effect.

[1] 1,2,3,4,10,10-hexachloro-1:4, 5:8-diendomethano-1,4,4a,5,8,8a-hexahydronaphthalene. (J. Hyman Co.)
[2] 1,2,3,4,10,10-hexachloro-6, 7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonapthalene. (J. Hyman Co.)

Table 2.—Effect of 75 per cent gamma benzene hexachloride from lindane as wet applications on two varieties of large lime beans grown in pasteurized soil at Davis: treated May 10, 1949, planted May 19, 1949.

Treatment	Dosage in Ounces per 100 Pounds Seed	Emergence Per Cent	Average Seedling Weights			Mean Emergence Period in Days
			With Cotyledons	Without Cotyledons	Cotyledon Weight	
		Fordhook Concentrated Bush Bean				
Untreated	—	93.3	7.59	6.55	1.04	9.26
Lindane[1]	0.66	88.3	6.82	5.46	1.36	9.91
Lindane	1.33	68.3	5.72	3.74	1.98	10.27
Least significant difference:	5% level	1.9	0.51	0.53		0.54
	1% level	2.6	0.70	0.73		0.75
		Ventura Large Lima Bean				
Untreated	—	76.8	6.31	5.08	1.23	10.04
Lindane	0.66	79.2	6.34	5.00	1.34	9.95
Lindane	1.33	76.8	5.54	3.99	1.55	10.86
Least significant difference:	5% level	n.s.	0.49	0.45		n.s.
	1% level	n.s.	0.74	0.69		n.s.

[1] The dosage refers to the amount of 75 per cent gamma isomer from lindane.

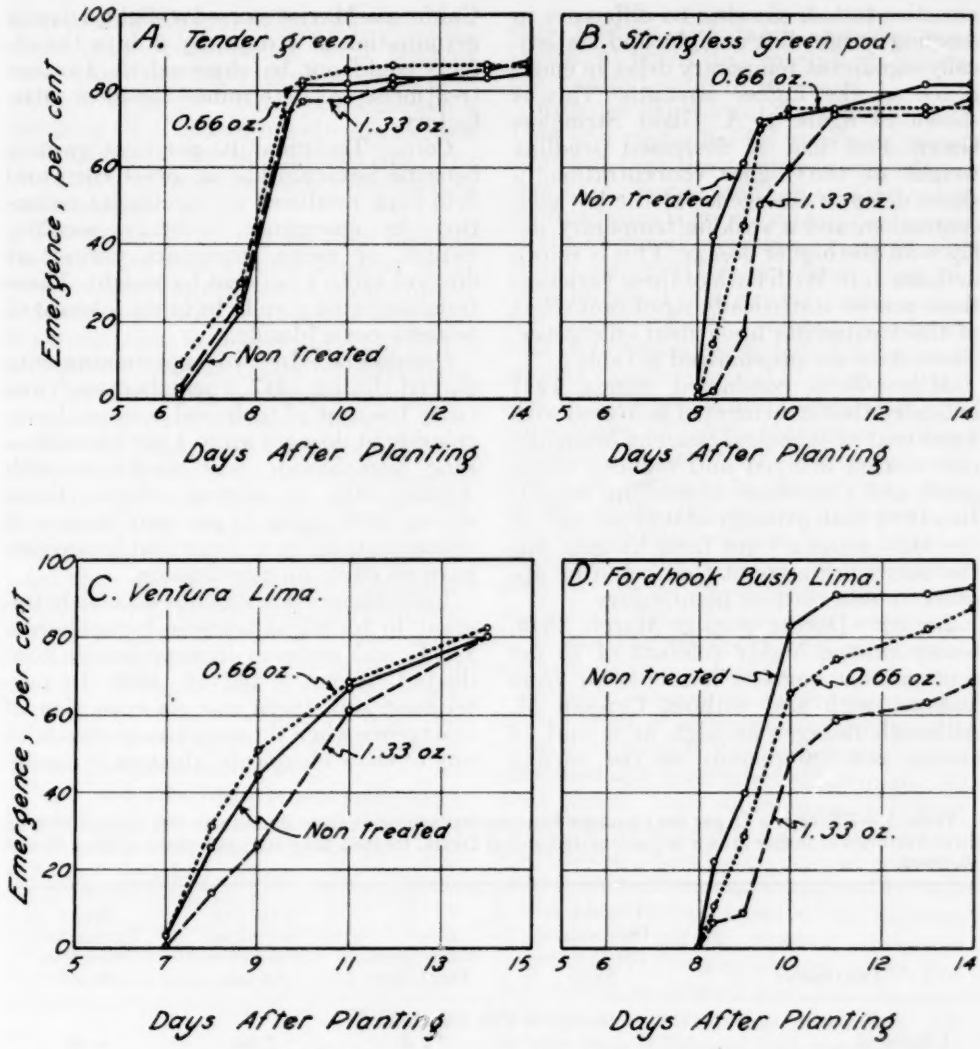

FIG. 1.—The comparative effect of two concentrations of 75% lindane upon the rate of emergence of four varieties of beans: A, Tendergreen, slight delay in emergence at higher dosage; B, Giant Stringless Green Pod, slight delay at lower dosage and significant delay at higher dosage; C, Ventura Lima, temporary delay at high dosage; and D, Fordhook Bush Lima, both dosages cause significant delay in emergence and reduced final emergence.

Stickers have been used experimentally to hold lindane and fungicides more tightly to large lima beans. Approximately 0.05 to 0.16 per cent by weight of a commercial sticker[1] was found useful in this regard.

Other Beans.—Tests run during May and June, 1947, using technical 10 per cent gamma benzene hexachloride, indicated that the tolerance of pink beans and red kidney beans was similar to that of baby lima beans. The maximum dosage was determined as 0.25 per cent by weight of seed.

During May, 1949, seed of three additional varieties of beans, Stringless Pole Blue Lake, Tendergreen, and Giant Stringless Green Pod, were treated with 75 per cent high gamma benzene hexachloride from lindane at 0.66 ounce and 1.33 ounces per 100 pounds of beans. Tendergreen was the most tolerant of the

[1] 10 per cent water solution of hydroxyethyl cellulose. (Carbide and Carbon Chemical Corporation.)

varieties tested, showing no difference in seedling weight but a slight and statistically significant temporary delay in emergence at the higher strength. This is shown in figure 1, A. Giant Stringless Green Pod had a decreased seedling weight at the higher concentration, a slight delay in emergence at the low concentration, and a striking temporary delay with the higher dosage. This is shown in figure 1, B. With both of these varieties, there was no statistically significant effect of the treatments upon final emergence. These data are summarized in table 3.

Milo.—Tests conducted during 1947 indicated that treatment of milo seed with 1 per cent of technical benzene hexachloride caused delayed and reduced emergence and a decrease in seedling weight. In a 1949 trial, a dosage of 0.25 per cent of the high gamma form from lindane was the maximum amount that could be applied to milo without plant injury.

Barley.—During tests in March, 1949, barley proved highly tolerant of 25 per cent gamma benzene hexachloride from lindane, with and without Ceresan M. Although dosages as high as 8 and 16 ounces per 100 pounds on the variety California Mariot caused a slight delay in germination at 4 days, by 6 days the effects could not be observed. A 4 ounce treatment was determined the most satisfactory.

Corn.—Technical 10 per cent gamma benzene hexachloride on sweet corn and field corn produced no significant reduction in emergence, average seedling weight, or mean emergence period, at dosages up to 1 per cent by weight. These tests indicated corn to be fairly tolerant of benzene hexachloride.

Cucumbers.—In two experiments conducted during 1947, cucumber seed was fairly tolerant of technical benzene hexachloride at dosages up to 1 per cent. Benzene hexachloride was combined with Arasan with no adverse effects. Trials during 1949, using 75 per cent lindane at concentrations up to 1 per cent by weight, gave no effect on germination.

Cantaloupe.—Cantaloupe was fairly tolerant to technical benzene hexachloride, DDT, and semesan in experiments conducted August 5 and 13, 1946. In pasteurized soil, there was no reduction of emergence when the seed was treated with any of these chemicals, alone or in combi-

Table 3.—Effect of a 75 per cent gamma benzene hexachloride from lindane as wet applications on three varieties of beans grown in pasteurized soil at Davis: treated May 10, 1949, planted May 17 and 19, 1949.

Treatment	Dosage in Ounces per 100 Pounds Seed	Emergence Per Cent	Average Seedling Weight in Grams	Mean Emergence Period in Days
		Stringless Pole Blue Lake		
Untreated	—	77.5	2.09	9.06
Lindane[1]	0.66	78.3	2.18	8.87
Lindane	1.33	76.7	1.79	9.77
Least significant difference:	5% level	n.s.	0.15	n.s.
	1% level	n.s.	0.22	n.s.
		Tender green		
Untreated	—	83.3	4.05	7.95
Lindane	0.66	85.8	3.99	7.94
Lindane	1.33	86.0	4.11	8.45
Least significant difference:	5% level	n.s.	n.s.	0.43
	1% level	n.s.	n.s.	0.61
		Giant Stringless Green Pod		
Untreated	—	75.8	3.38	8.77
Lindane	0.66	81.7	3.57	9.20
Lindane	1.33	77.5	3.12	9.82
Least significant difference:	5% level	n.s.	0.32	0.33
	1% level	n.s.	0.45	0.46

[1] The dosage refers to the amount of 75 per cent gamma isomer from lindane.

nation. In *Pythium* infested soil, Semesan alone or in combination with benzene hexachloride or DDT gave excellent control of both pre- and post-emergence damping off. The two insecticides showed no fungicidal action but did not reduce the protective value of semesan when used in combination.

Tomatoes.—Tests during 1949 indicate that a 50 per cent gamma benzene hexachloride from lindane can be safely applied to tomato seed with no delay or reduction in germination, at dosages of 0.125 to 1.0 per cent by weight. Yellow cuprous oxide was combined with benzene hexachloride with no apparent adverse effects.

Okra.—During 1948 tests, 0.25 and 0.5 per cent of a 25 per cent gamma benzene hexachloride from lindane was used on okra seed with no significant effect on germination or the rate of emergence.

Lettuce.—Lettuce seed was tolerant to 0.125 to 1.0 per cent by weight of technical 10 per cent gamma benzene hexachloride. No delay in emergence was recorded at any of the dosages tried in the 1947 tests. There is probably no reason to treat lettuce seed, as wireworms do not ordinarily feed on the germinating seed.

Peas.—Limited tests on pea seed, using technical 10 per cent gamma benzene hexachloride, were made during 1946 and 1948. The first test, using 1 per cent by weight of the crude material, resulted in a slight retardation of germination. A later test indicated no effect on emergence when the seeds were treated with 0.25 and 0.5 per cent by weight of the same material.

Cotton.—Tests conducted during 1949 on mechanically de-linted cotton seed, using 0.66 ounce to 5.28 ounces per 100 pounds of seed of 75 per cent gamma benzene hexachloride from lindane, applied as wet treatments, indicated no observable effect on average seedling weight or on the mean emergence period.

TOXICITY TO WIREWORMS.—In laboratory tests, 100 per cent of wireworms became sluggish, sickly, or dead within 2 weeks after being confined with baby lima bean seed treated with 0.25 per cent of 25 per cent benzene hexachloride from lindane. This chemical used as a seed treatment apparently kills largely by contact action, although the stomach poison and fumigant action of the chemical cannot be overlooked. Affected wireworms stop feeding and rarely recover, even though at times they continue in a moribund state from 8 to 16 weeks.

From an experiment started March 17, 1949 and continued for 10 weeks, it was apparent that the gamma isomer of benzene hexachloride used as a seed treatment on lima beans is the most toxic component of the chemical. Seed were sprayed with 50 per cent wettable powders, which had been prepared in a mortar, using a neutral, fibrous talc as a diluent. No significant differences were found between a gamma isomer material of 99.95 per cent and of 100 per cent. Technically pure alpha, beta, and delta isomers of benzene hexachloride exhibited little or no evidence of toxicity to wireworms. Beta isomer at .025 per cent of a 50 per cent wettable powder on lima beans however indicated a slight effect on wireworms after 4 weeks. Seed treatments with aldrin and dieldrin, however, were toxic to them. The results of this experiment are summarized in table 4.

Detailed laboratory studies were made of the effect of different seed treatments upon the larvae of *Limonius canus*, when examined at 2 week intervals through a 10 week period. Tests summarized in table 5 on Wilbur lima beans, okra, sugar beets, and tomato indicate the type of data obtained from these experiments. It was found that larvae affected by benzene hexachloride rarely recover, although they may live for a number of weeks. For this reason, moribund larvae can be considered in determining mortality. Although both 0.125 and 0.25 per cent of 25 per cent benzene hexachloride from lindane on lima beans gave 100 per cent moribund larvae within 2 weeks after their introduction, a total period of 6 weeks elapsed before they were dead. Higher percentages of benzene hexachloride were needed on sugar beet seed for adequate wireworm kills, perhaps because of the uneven nature of the seed surface and the greater absorption of the chemical. *L. canus* larvae did not feed readily on tomato seed, and for this reason the mortalities were lower than for most seed treatments at comparable dosages. Parathion at 1 per cent of a 25 per cent wettable powder sprayed on sugar beet seed gave low mortality in these tests, as did chlordan at 2 per cent of a 40 per cent wettable powder.

Table 4.—Effect of chemical seed treatments of baby lima beans on larvae of *Limonius canus*.[1]

Treatment	Dosage in Per Cent by Weight of 50 Per Cent Wettable Powder	Per Cent Wireworm Mortality Following Introduction of Wireworms									
		2 Weeks		4 Weeks		6 Weeks		8 Weeks		10 Weeks	
		M[2]	D	M	D	M	D	M	D	M	D
High gamma benzene hexachloride, 99.95% gamma	0.125	100.0	0.0	100.0	0.0	91.7	8.3	0.0	100.0	0.0	100.0
High gamma benzene hexachloride, 100% gamma	0.125	83.3	0.0	100.0	0.0	83.3	16.7	0.0	100.0	0.0	100.0
High gamma benzene hexachloride, 100% gamma	0.25	100.0	0.0	100.0	0.0	75.0	25.0	0.0	100.0	0.0	100.0
Technically pure alpha isomer of benzene hexachloride	0.25	0.0	8.3	0.0	8.3	8.3	8.3	0.0	16.7	0.0	16.7
Technically pure alpha isomer of benzene hexachloride	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
Technically pure beta isomer of benzene hexachloride	0.25	0.0	0.0	0.0	8.3	8.3	8.3	8.3	8.3	0.0	25.0
Technically pure beta isomer of benzene hexachloride	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.3
Technically pure delta isomer of benzene hexachloride	0.25	0.0	0.0	0.0	8.3	0.0	8.3	0.0	16.7	8.3	16.7
Technically pure delta isomer of benzene hexachloride	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dieldrin	0.125	75.0	8.7	75.0	16.7	41.7	50.0	33.3	66.7	33.3	66.7
Aldrin	0.125	91.7	0.0	75.0	16.7	41.7	50.0	33.3	66.7	58.3	41.7
No treatment	—	0.0	0.0	0.0	0.0	6.7	0.0	0.0	16.7	0.0	16.7

[1] Larvae confined with treated seeds in 4-ounce salve cans in the laboratory and held at 54° F.
[2] M = moribund; D = dead.

Table 5.—Effect of chemical treatments of several kinds of seeds on larvae of *Limonius canus*.[1]

Treatment	Dosage as Per Cent of Weight of Seed	Per Cent Wireworm Mortality Following Introduction of Wireworms							
		2 Weeks		4 Weeks		6 Weeks		8 Weeks	
		M[2]	D	M	D	M	D	M	D
Wilbur Baby Lima Beans, July 28, 1948									
No treatment	—	0.0	0.0	0.0	0.0	0.0	0.0		
Lindane, 25%[3]	0.125	100.0	0.0	33.3	66.7	0.0	100.0		
Lindane, 25%	0.25	100.0	0.0	33.3	66.7	0.0	100.0		
Okra, July 28, 1948									
No treatment	—	0.0	0.0	0.0	0.0	0.0	0.0		
Lindane, 25%	0.25	66.7	0.0	33.3	66.7	0.0	100.0		
Lindane, 25%	0.50	100.0	0.0	26.7	73.3	50.0	50.0		
Sugar Beets, July 29, 1948									
No treatment	—	0.0	0.0	0.0	0.0	0.0	0.0		
Lindane, 25%	0.25	33.3	0.0	33.3	16.7	0.0	50.0		
Lindane, 25%	0.50	50.0	0.0	100.0	0.0	50.0	50.0		
Lindane, 25%	2.00	83.3	16.7	50.0	50.0	16.7	83.3		
Parathion, 25% wettable powder	1.00	33.3	0.0	33.3	0.0	0.0	16.7		
Chlordane, 40% wettable powder	2.00	16.7	0.0	50.0	16.7	66.7	33.3		
Pearson Tomato Seed, February 28, 1949									
No treatment	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cuprous oxide	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cuprous oxide, Lindane, 50%	1.5 0.125	58.3	16.7	75.0	25.0	41.7	58.3	16.7	83.3
Cuprous oxide, Lindane, 50%	1.5 0.25	66.7	16.7	41.7	50.1	33.3	66.7	16.7	83.3
Cuprous oxide, Lindane, 50%	1.5 0.50	58.3	16.7	50.0	50.0	16.7	66.7	0.0	100.0
Cuprous oxide, Lindane, 50%	1.5 1.00	50.0	33.3	16.7	83.3	16.7	83.3	0.0	100.0

[1] Larvae confined with treated seeds in 4 ounce salve cans in the laboratory and held at 54° F.
[2] M = moribund; D = dead.
[3] Refers to amount of 25 per cent or 50 per cent (as designated) of gamma isomer from lindane.

Table 6.—Effect of lindane and aldrin seed treatments of lima beans and cucumber on mortality of *Limonius californicus* larvae.[1]

Treatment	Dosage in Per Cent of Weight of Seed	Per Cent Wireworm Mortality Following Introduction of Wireworms									
		2 Weeks		4 Weeks		6 Weeks		8 Weeks		10 Weeks	
		M[2]	D	M	D	M	D	M	D	M	D
		Baby Lima Beans, January 28, 1948									
No treatment	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lindane, 50% (dry mix)[3]	0.125	75.0	8.3	58.3	33.3	41.7	58.3	41.7	58.3	8.3	91.7
Lindane, 50% (wet mix)	0.125	100.0	0.0	83.3	16.7	83.3	16.7	50.0	50.0	0.0	100.0
Lindane, 25% (wet mix)	0.25	66.7	0.0	100.0	0.0	83.3	16.7	66.7	33.3	25.0	75.0
Aldrin 25% wettable powder (dry mix)	0.25	100.0	0.0	83.3	16.7	66.7	33.3	58.3	41.7	8.3	91.7
		Cucumber, April 29, 1949									
No treatment	—	0.0	0.0	0.0	0.0	0.0	0.0				
Lindane, 75%	0.25	75.0	25.0	75.0	25.0	25.0	75.0				
Lindane, 75%	0.50	66.7	33.3	41.7	58.3	16.7	83.3				
Lindane, 75%	1.00	75.0	25.0	91.7	8.3	50.0	50.0				

[1] Larvae confined with treated seeds in 4-ounce salve cans in the laboratory and held at 54° F.
[2] M = moribund; D = dead.
[3] Refers to amount of 25%, 50%, or 75% (as designated) of gamma isomer from lindane.

Tests were also conducted on various seeds using larvae of *Limonius californicus*. The results obtained from benzene hexachloride were similar to those obtained on *L. canus*. There was some indication that a wet application on lima beans was superior to the dry treatment. Percentages of 0.25 to 1 per cent of 25 per cent gamma isomer from lindane on cucumber seed gave adequate control of *L. californicus*. (Table 6.)

The effect of the storage of seed treated with benzene hexachloride in relation to insecticidal efficiency was determined for sugar beets. Sugar beet seed treated March 18, 1948 with one per cent of 25 per cent gamma benzene hexachloride from lindane was tested on larvae of *L. canus* on January 14, 1949. Ten months' storage in a quart jar with little ventilation resulted in a 50 per cent loss of insecticidal efficiency. Within 4 weeks, 100 per cent of the larvae were moribund, but 12 weeks elapsed before all were dead.

Slurry treatments, using a 75 per cent gamma benzene hexachloride from lindane, indicated that a dosage of 0.33 pound to 100 pounds of sugar beet seed gave a mortality of *L. canus* comparable to treatments with 1 pound of 25 per cent gamma material from the same source.

FIELD EXPERIMENTS.—One of the first field experiments dealing with seed treatments was made on sugar beet seed on April 13, 1947, at Woodland, California. Using a technical form of benzene hexachloride with 6 per cent gamma content, one lot was treated with 4 per cent by weight of the chemical as a dry powder and another lot with 4 per cent moisture. Both treatments gave a high mortality of *Limonius canus* larvae.

This experiment and later observations of commercially treated sugar beet seed led to field tests to determine the manner in which the wireworms are killed, the determination of the percentage of wireworms killed, the percentage of reduction in the total wireworm population, the effect of treatment on emergence and seedling weight, the effect on final yield, and the efficacy of combination fungicide-insecticide treatments. Because of many variable factors, it was difficult to evaluate fully the effect of chemicals on seed tested under field conditions, but it was soon apparent that field results closely paralleled laboratory investigations. The effects on plant growth could not be observed as easily in the field, however. There also were differences in the rate and manner of killing wireworms.

In most cases, the effectiveness of a seed treatment for wireworm control depends upon the percentage of wireworms attracted to the seed and upon the rapidity of insecticidal action. Wireworms were affected in the field within a few days; many were found on the surface of the soil as if trying to escape from the chemical. Many others were desiccated before they could reach adequate moisture. Worms remaining near the treated seed appeared nervous at first, later became sluggish, and took as long as 6 weeks to die. Where the old parts of such seeds as sugar beets or spinach remained in the ground, benzene hexachloride left on the seeds was still able to kill wireworms from 2 to 4 months following planting.

A series of experiments was conducted on sugar beets at Lockeford during 1948, using benzene hexachloride, parathion, and chlordan as seed treatments. It was found that in general the percentage of wireworms killed increased directly with the dosage of benzene hexachloride, ranging from 50 per cent mortality with 0.25 per cent of the 25 per cent gamma material from lindane to 93 per cent with 1 per cent of the same material. Parathion effected a satisfactory reduction of wireworms in this experiment but chlordan gave poor control. The number of plants per foot of row closely paralleled the wireworm toxicity obtained but showed the definite superiority of lindane. (Table 7.)

A series of replicated seed treatment experiments on Wilbur baby lima beans was conducted at Crows Landing, California, during 1948, using technical benzene hexachloride, lindane, and parathion. Noted in these experiments, and substantiated with soil application experiments, was the fact that technical benzene hexachloride proved more toxic to wireworms at low concentrations than equivalent dosages of lindane. One per cent of 25 per cent gamma benzene hexachloride from lindane in these experiments was comparable in toxicity to 0.125 per cent of a technical grade benzene hexachloride. Higher dosages of the technical grade material apparently repel wireworms and produce less insecticidal toxicity. These tests gave no indication of delayed emergence or other adverse effects on the growth of the beans, as is indicated in the final yields. (Table 8.)

In order to test the effect of seed treatment under different conditions, the same lots of seed used in the Crows Landing experiments were planted at Davis on August 21, 1948, in a Yolo clay loam soil using five replications of 10 feet of single row. Also included was a lot of seed treated on August 18, 1948, with 0.25 per cent of 25 per cent gamma benzene hexachloride from lindane. Counts made on September 14, 1948, indicated that parathion at 1 per cent and 25 per cent gamma isomer benzene hexachloride from lindane at 0.5 and 1 per cent, seriously damaged bean plants. This was reflected in a reduction in average seedling weight. There was no indication that seed treated with 0.25 per cent of 25 per cent gamma benzene hexachloride from lindane and

Table 7.—Effect of chemical treatments of sugar beet seed on the mortality of *Limonius canus* larvae, and extent of plant damage.[1]

Treatment[2]	Dosage in Per Cent of Weight of Seed	Average Number Live Worms per Foot of Row[3]	Per Cent Mortality	Average Number Plants per Foot of Row
No treatment	—	2.75	—	0.69
Lindane, 25%[4]	0.25	1.38	49.8	1.45
Lindane, 25%	0.50	0.66	76.0	1.44
Lindane, 25%	1.00	0.19	93.1	1.74
Lindane, 25%	2.00	0.44	84.0	1.63
Parathion, 15% wettable powder	1.00	0.41	85.1	1.05
Parathion, 15% wettable powder	2.00	0.34	87.6	1.39
Chlordane, 50% wettable powder	1.00	2.66	3.3	0.72

[1] Planted in the field at Lockeford, California on March 23, 1948.
[2] Seed mixed in cement mixer, using the chemicals in suspension in water to make 4% of total weight of seed. All seed treated with phygon at 1.0% by weight.
[3] Determined from 16 siftings for each treatment of an area 1 foot long×6 inches wide×6 inches deep in the plant rows.
[4] Refers to amount of 25% of gamma isomer from lindane.

Table 8.—Effect of chemical seed treatments of baby lima beans on the control of *Limonius canus* larvae, extent of plant injury, and yield.[1]

Treatment	Dosage in Pounds Per 100 Pounds Bean Seed	Per Cent Plants Damaged		Average Number Live Worms Per Foot Row on June 10, 1948	Per Cent of Worms Dead on June 10, 1948	Average Yield of Wilbur Baby Lima Beans in Pounds Per Acre
		June 11, 1948	August 11, 1948			
Lindane, 25%[2]	0.25	0.0	7.3	0.17	75.0	1,679
Lindane, 25%	0.50	0.0	7.3	0.06	90.0	1,749
Lindane, 25%	1.00	0.0	7.3	0.06	94.7	2,005
Benzene hexachloride, 10% gamma, technical grade	0.125	0.0	12.0	0.06	95.2	1,952
Benzene hexachloride, 10% gamma, technical grade	0.25	0.0	14.0	0.33	73.9	1,801
Benzene hexachloride, 10% gamma, technical grade	0.50	3.3	11.3	0.22	85.7	1,847
Parathion, 15%, wettable powder	0.50	9.8	22.7	0.44	52.9	1,662
Parathion, 15%, wettable powder	1.00	34.5	18.7	0.28	76.2	1,813
No treatment	—	47.0[3]	27.3	1.06	0.0	1,659
No treatment	—	16.1	14.7	1.00	0.0	1,894
Least significant difference:						
5% level						n.s.
1% level						n.s.

[1] Seed planted in the field at Crows Landing, California, on May 13, 1948.
[2] Refers to amount of 25 per cent gamma isomer from lindane.
[3] The apparent discrepancy in certain instances in percentage of plants injured on June 11 as compared with August 13 is probably due to two factors: (1) killing of certain plants; and (2) recovery of others so that damage on August 13 was not detected.

stored for 3 months had any greater effect on germination or seedling weight than seed treated with the same dosage and material 3 days prior to planting. The greater damage obtained in these experiments in comparison with the Crows Landing tests may be due to the higher air and soil temperatures during the germinating period. (Table 9.)

During May, 1949, there was an opportunity to observe the effect of a combination insecticide-fungicide treatment of milo seed under field conditions. Milo seed was treated on a large scale with 1.33 ounces of 75 per cent gamma benzene hexachloride from lindane and Phygon paste at the equivalent rate of 2 ounces of Phygon XL to 100 pounds of seed. This was planted in the field, using 5 planting boxes for untreated seed and 3 planting boxes for treated seed. On May 23, 1949, at the late 3- to early 4-leaf stage, a count indicated 2.12 seedling per foot of row in the non-treated area to 9.44 seedlings per foot of row in the treated areas, or a ratio of 4.45 to 1. This increase was due primarily to wireworm control, but other important factors were the control of *Pythium* seed decay and the reduction of seed borne *Fusarium moniliforme*. The treatment had little effect, however, on the *F. moniliforme* that was soil borne.

EFFECT OF SEED TREATMENT ON TOTAL POPULATION OF WIREWORMS.—The effect of seed treatment on the total population of wireworms was studied during 1949 at Woodland, California. Sugar beet seed was treated and planted February 15, 1949, using 25 per cent gamma benzene hexachloride from lindane at the rate of 1 pound to 100 pounds of seed. Soil samples were taken on April 18, 1949, at two levels: surface to 7 inches, and 7 to 13 inches. A total of 12 samples, 8 inches wide by 12 inches long, by 6 inches deep, were taken for each depth in adjacent treated and untreated areas. In the surface to 7 inch level, the untreated area had 2.5 wireworms (*Limonius canus*) and the treated area 1.33. In the 7 to 13 inch level, the untreated area had an average of 1.17 wireworms per sample, as compared to 0.66 in the treated area. These observations indicated that the effect of seed treatment was a reduction not only in the upper 6 inches but also in the *total* population of wireworms. Expressed as a percentage it represents a re-

Table 9.—Effect of chemical seed treatments of Wilbur baby lima beans on emergence and seedling weight.[1]

TREATMENT[2]	DOSAGE IN PER CENT OF WEIGHT OF SEED	AVERAGE TOTAL EMERGENCE PER 100 SEEDS PLANTED	AVERAGE SEEDLING WEIGHT IN GRAMS
No treatment	—	56.8	8.82
No treatment[3]	—	55.2	9.91
Lindane[4]	0.25	44.4	8.32
Lindane	0.50	45.6	7.05
Lindane	1.00	32.8	6.14
Technical benzene hexachloride, 10% gamma	0.125	54.4	7.84
Technical benzene hexachloride, 10% gamma	0.25	36.4	8.72
Technical benzene hexachloride, 10% gamma	0.50	22.0	6.54
Lindane[5]	0.25	38.4	7.08
Lindane[6]	0.25	37.6	7.57
Parathion, 15% wettable powder	0.50	37.6	7.51
Parathion, 15% wettable powder	1.00	27.6	6.95
Least significant difference at:			
5% level		11.6	1.41
1% level		15.3	1.86

[1] Planted in the field at Davis, California, August 21, 1948, and the plants pulled September 14, 1948.
[2] All treated May 6, 1948, with insecticide and Spergon at 0.25 per cent by weight except as noted.
[3] Not Spergon treated.
[4] Refers to amount of 25 per cent gamma isomer from lindane.
[5] Treated on August 18, 1948—no Spergon.
[6] Treated on August 18, 1948 with Spergon at 0.25 per cent by weight.

duction of 45 per cent of the total population of wireworms (those not passing through a 16 mesh screen) with one seed treatment. No wireworms were found in the 13 to 19 inch level at this particular time.

DISCUSSION.—The foregoing experiments indicate that of the chemicals tested, the high gamma form of benzene hexachloride, or lindane, is a promising material when used as a seed treatment for wireworm control and can be combined with certain fungicidal seed protectants. Such a treatment not only is economical but reduces to a minimum the possible adverse effects of accumulating large amounts of chlorinated chemicals in the soil. Seed treatment is regarded not as a permanent control measure but as a method of obtaining temporary control and a good stand of plants. For this reason, a seed treatment has to be repeated for each crop. A decided variance was noted in the tolerance of different seeds to lindane, and for this reason the dosage has to be varied accordingly. On the basis of tolerance to the seed and effect on wireworms, the following tabulation presents the tentative dosages for the use of lindane as a seed treatment.

If a 75 per cent formulation of lindane is used in a spray or in a slurry treater, the dosages in the above tabulation should be reduced to one-third the amounts stated.

Table 10.—Dosages of lindane suggested for seed treatment.

CROP	DOSAGE OF BENZENE HEXACHLORIDE OF 25 PER CENT GAMMA ISOMER FROM LINDANE, EXPRESSED IN PER CENT BY WEIGHT IN SEED
Sugar beets	1.0
Cotton	0.50
Lettuce	0.50
Tomato	0.50
Cucumbers	0.25
Cantaloupes	0.25
Corn	0.25
Peas	0.25
Okra	0.25
Milo	0.25
Barley	0.25
Baby lima beans and most other beans	0.125–0.25
Large lima beans	0.0625–0.125
Wheat	0.0625–0.125

SUMMARY.—Studies begun in 1946 have been made to determine the efficacy of seed treatments for the control of wireworms in California.

Laboratory tests in conjunction with field work indicated that of the chemicals tested—namely, parathion, lindane, technical benzene hexachloride, aldrin, dield-

rin, DDT, and chlordan—the purified gamma isomer of benzene hexachloride, or lindane, was the most promising from the standpoint of tolerance, safety, and insecticidal efficiency. Of the others tested, aldrin, dieldrin, and parathion need further investigation, particularly in regard to phytotoxicity.

Of the different methods used in treating seed with lindane, liquid applications, such as suspensions or solutions, were found more adaptable because of the greater adherence and evenness of distribution of the chemical on the seed, greater safety to the operator, and insecticidal efficiency.

The tolerances of different seeds to lindane were found to vary markedly. Injury from lindane at dosages greater than those suggested included delay in germination, stunting of the plants, non-absorption of the cotyledons in the case of certain varieties of beans, and reduction in seedling weight.

The insecticidal effectiveness of chemical seed treatments was determined in the laboratory by exposing wireworms to treated seeds in 4-ounce salve cans and, in addition, by checking mortality under field conditions.

Laboratory work using *Limonius canus* larvae indicated that of the pure isomers of benzene hexachloride tested—namely, alpha, beta, delta, and gamma—the gamma isomer was the most effective in killing wireworms.

Field observations suggested that not all wireworms are equally affected by the gamma isomer of benzene hexachloride. This finding was confirmed by exposing several species to soil treated with lindane. The most susceptible was an *Aeolus* sp., followed, in order of their decreasing susceptibility to lindane, by *Limonius canus*, *L. californicus*, and *Anchastus* sp.

Combination insecticide-fungicide treatments were feasible and often resulted in increased stands in the field, due to a dual control of wireworms, seed borne fungi, or pre-emergence damping off organisms. Lindane was combined satisfactorily with arasan, semesan, spergon, ceresan M, phygon, and yellow cuprous oxide.

Field tests indicated that one seed treatment at the suggested dosages of lindane killed from 70 to 95 per cent of the wireworms within the immediate area of of the treated seed and reduced the population of wireworms about 50 per cent.

LITERATURE CITED

Brooks, James W., and Lauren D. Anderson. 1947. Toxicity tests of some new insecticides. JOUR. ECON. ENT. **40**(2): 220–8.

Dogger, J. R., and J. H. Lilly. 1949. Seed treatment as a means of reducing wireworm damage to corn. JOUR. ECON. ENT. **42**(4): 663–5.

Hocking, B. 1949. Effect of crude benzene hexachloride on wheat seedlings. Nature **163**(4149): 731.

Kostoff, D. 1948. Atypical growth, abnormal mitosis, polyploidy, and chromosome fragmentation induced by hexachlorocyclohexane. Nature. **162**(4126): 845.

1949. Induction of cytogenetic changes and atypical growth by hexachlorocyclohexane. Science. **109**(2836): 467–8.

Lange, W. H. 1947. New developments in soil insecticides. Agr. Chemicals. **20**(9): 29–33, 68–9.

Lange, W. H., E. C. Carlson, and L. D. Leach. 1949. Wireworms in lima beans controlled with high gamma benzene hexachloride seed treatment. Calif. Agr. **3**(5): 5, 10.

Leach, L. D., and P. G. Smith. 1945. The effect of seed treatment on protection, rate of emergence, and growth of garden peas. Phytopath. **35**: 191–206.

McLeod, W. S. 1946. Hexachlorocyclohexane in the control of the onion maggot. JOUR. ECON. ENT. **9**(5): 631–7.

1946a. Effect of hexachlorocyclohexane on onion seedlings. JOUR. ECON. ENT. **39**(6): 815.

Morrison, H. E., H. H. Crowell, S. E. Crumb, Jr., and R. W. Lauderdale. 1948. The effects of certain new soil insecticides ojplants. JOUR. ECON. ENT. **41**(3): 374–8.

Stoker, Rosemary I. 1948. The phytotoxicity of DDT and of benzene hexachloride. Ann. App. Biol. **34**(1): 110–22.

Thomas, C. A. 1940. The biology and control of wireworms, a review of the literature. Pa. State Coll. 392.

Comparison of Sprays and Dusts for Grasshopper Control[1]

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Results of tests conducted at this Station during 1947 and 1948 and reported in the Journal of Economic Entomology indicated that toxaphene, chlordane, benzene hexachloride and parathion applied as dusts were effective against grasshoppers. The use of poison bait has been discontinued in Central Texas and planters are more generally using toxaphene, chlordane and benzene hexachloride to effectively control this pest. Until 1949 these materials were applied in dust form, however, this year toxaphene was widely used in spray form. Many of the commercially treated fields were observed and in most instances excellent control was obtained with both sprays and dusts. During periods of windy weather when dusts could not be applied effectively, the sprays gave good results. Both ground machinery and airplanes were used in the application of both dust and sprays.

The laboratory and field tests herein reported were conducted at College Station, Texas during the spring of 1949 in order to compare the effectiveness of several insecticides applied as both sprays and dusts. Mixed populations of grasshoppers occurred but the majority were *Melanoplus differentialis* (Thos.). This species was used in the laboratory tests. Untreated cages or plats were used in all experiments. The percentages of mortality were calculated by Abbott's formula while the percentages of reduction were used to evaluate the treatments in the field.

Laboratory Tests.—These tests were conducted for the purpose of comparing the toxicity of (1) benzene hexachloride (all isomers), (2) lindane, (3) chlordane, (4) toxaphene and (5) parathion. In determining the relative toxicity of the materials as a contact, oil miscible concentrates applied as emulsion sprays were used against nymphs. Field collected nymphs were placed in coarse wire cages for spraying. The sprays were forced through a nozzle at 35 pounds pressure into a spraying chamber containing the caged nymphs. An even distribution of spray was facilitated by slowly rotating the bottom of the cylinder. All sprays were applied at the rate of ten gallons per acre and were allowed to settle 20 seconds before removing the insects. The nymphs were immediately transferred to clean cages and thereafter given clean food. Observations for dead individuals were made during a 48 hour period. Varying dosages of each material were applied entailing the use of approximately 400 individuals, in order, to determine each toxicity curve.

The toxicity curves shown in figure 1 were calculated by the method described by Bliss (1938). These data show the comparative effect of these materials as contact poisons. Benzene hexachloride and parathion proved to be more effective as contact poisons than did either chlordane or toxaphene. The benzene hexachloride containing all isomers proved twice as toxic as lindane containing only the gamma isomer.

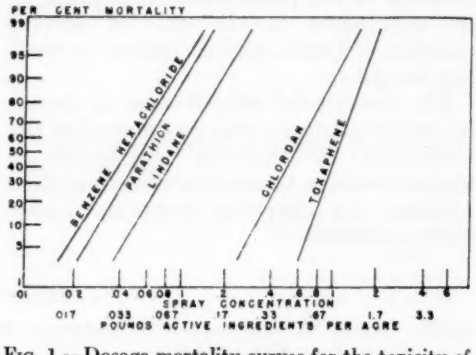

Fig. 1.—Dosage-mortality curves for the toxicity of the insecticides indicated to grasshopper nymphs.

The MLD for each insecticide used as a spray and dust is shown in table 1. The MLD's for the materials applied in dust form were determined by Gaines & Dean (1948) and are shown in table 1 for comparison. The materials were considerably more toxic as contact poisons when applied as emulsion sprays than when applied as dusts.

Tests were also conducted to determine the comparative effectiveness of the materials as contact poisons when applied to

[1] Technical contribution 1245 Texas Agricultural Experiment Station.

[2] Thanks are due M. A. Cevallos for conducting the laboratory tests.

Table 1.—The median lethal dose of insecticides as indicated for first to third instar grasshopper nymphs following contact sprays and dusts.

Treatment	MLD, Pounds Active Ingredients per Acre	
	Spray Emulsions	Dust
Toxaphene	1.17	1.73
Chlordane	.49	1.49
Parathion	.05	.17
Benzene Hexachloride	.04	.17
Lindane	.08	

adult grasshoppers in the form of spray emulsions made from oil miscible concentrates and wettable powders. These data are shown in table 2. It required higher dosages to kill adult grasshoppers than was required to kill the young nymphs. All the materials tested proved to be equally effective when applied as emulsion sprays as when applied as wettable powder sprays.

FIELD TESTS.—These tests, tables 3 and 4, were conducted for the purpose of comparing (1) chlordane, (2) toxaphene, (3) benzene hexachloride, (4) parathion, (5) aldrin[2] and (6) dieldrin[3] under field conditions. The dust applications were made with rotary hand guns early in the morning while the air was calm and dew was present. The sprays were applied later in the day with a compressed air sprayer equipped with a valve

Table 2.—Mortality of adult grasshoppers following contact spray applications.

Insecticide	Dose Pounds Active Ingredient per Acre	Per Cent Mortality	
		Sprays, Wettable Powder Suspensions	Spray Emulsions, Miscible Oil Concentrates
Benzene hexachloride	0.08	14.7	17.7
	0.17	19.0	29.0
	0.25	38.7	22.7
Chlordane	0.83	7.4	7.8
	1.66	38.2	43.0
	2.49	100.0	53.4
Toxaphene	0.83	11.1	10.1
	1.66	14.7	24.6
	2.49	32.3	62.0
Parathion	0.08	17.6	14.1
	0.17	20.5	36.2
	0.25	30.3	35.5

[2] 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene.

[3] 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8 dimethanonaphthalene ($C_{12}H_8OCl_6$).

Table 3.—Mortality of first and second instar grasshopper nymphs following spray and dust applications in weed field.

Material	Method of Application	Lbs. Active Ingred. per Acre	Per Cent Reduction Days After Application						
			1	3	4	5	7	10	14
Chlordane	Spray	.56	64.2	84.2	96.8	84.2	88.4	96.8	96.8
	Spray	.85	96.0	98.6	98.6	96.0	98.0	99.3	98.0
Toxaphene	Spray	.49	98.7	98.6	100.0	98.7	90.9	97.4	93.5
	Spray	1.17	97.0	100.0	99.0	97.0	99.0	98.0	97.0
	Spray[1]	1.5	87.1	100.0					
	Dust	1.10	33.3	33.3	72.2	33.3	25.0	86.1	58.3
	Dust	1.60	56.8	50.8	77.3	60.6	89.4	96.2	90.2
Aldrin	Spray	.12	84.1	98.4	96.8	95.2	98.4	98.4	98.4
	Spray	.21	95.87	98.2	100.0	97.7	99.0	100.0	99.5
Dieldrin	Spray	.10	98.3	100.0	100.0	98.8	98.2	99.4	100.0
	Spray	.24	100.0	81.8	83.6	38.2	98.1	80.0	76.4
Benzene hexachloride	Spray	.15	82.5	83.9	96.4	91.8	93.2	97.8	95.7
	Spray	.34	99.6	98.5	99.6	98.8	100.0	99.2	98.8
Parathion	Spray	.10	99.6	95.9	99.2	96.3	97.1	99.5	98.7
	Spray	.22	86.6	100.0	100.0	88.9	73.1	98.8	94.2

[1] Applied by airplane.

Table 4.—Mortality of first and second instar grasshopper nymphs following spray and dust applications in weed fields.

Material	Method of Application	Lbs. Active Ingred. per Acre	Per Cent Reduction Days After Application							
			1	2	3	4	6	8	10	13
Chlordane	Spray	.84	86.9	89.8	96.0	92.3	94.5	96.5	94.5	84.1
	Spray	1.10	90.9		98.7				98.6	
	Spray	1.17	90.9	95.9	98.0	100.0	98.3	100.0	94.2	83.5
Toxaphene	Spray	.65	47.2	74.1	79.2	78.2	85.6	89.3	68.5	52.8
	Spray	1.05	88.5	98.1	100.0	100.0	96.1	95.2	97.1	50.0
	Spray	.94	93.0		97.4				93.2	
	Dust	1.20	89.9	97.8	99.6					
	Dust	1.60	87.1	96.8	100.0					
Aldrin	Spray	.15	80.3	92.4	93.4	97.5	98.5	99.5	99.0	97.4
	Spray	.23	88.0	88.0	96.0	98.0	98.0	98.0	98.0	94.0
	Dust	.25	68.6	92.2	96.1					
	Dust	.42	98.1	94.4	98.1					
Dieldrin	Spray	.12	100.0	100.0	100.0	99.1	100.0	100.0	100.0	100.0
	Spray	.19	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Dust	.25	100.0	98.9	100.0					
	Dust	.38	100.0	97.2	98.6					
Benzene hexachloride	Spray	.17	85.8	83.9	86.3	87.8	92.2	89.6	82.5	91.9
	Spray	.37	93.5	92.2	87.6	85.6	91.5	92.2	89.5	65.3
Parathion	Spray	.11	97.3	95.2	94.5	88.4	95.9	87.6	87.6	84.4
	Spray	.19	100.0	99.2	98.4	97.6	97.6	96.0	96.0	98.4

which regulated the pressure at 40 pounds. Three cone nozzles, 20 inches apart were attached to the boom allowing complete coverage of the foliage. Moving at the rate of 5 miles per hour, this sprayer delivered approximately 5 gallons per acre. The tank was weighed before and after spraying each plat in order to ascertain the exact amount of material that was applied. In these tests, the insecticides acted both as a contact and as stomach poisons. It will be noted that a range of dosages was applied to the several replicates in order to compare the materials at more than one dosage. The plats were arranged in randomized blocks, each 0.10 acre in size, subject to nymphs migrating in from the untreated portion of the field. The population was estimated by sweeping each plat with a 16 inch insect net and the initial infestation averaged 200 nymphs per 50 sweeps.

The results of these field tests indicate that the low dosage, 8 ounces of either chlordane or toxaphene applied as a spray emulsion was effective against young hoppers. This dosage of 8 ounces active ingredient applied in spray form was about as effective as 1 pound of active ingredient applied in dust form. These dosages must be increased as the grasshoppers increase in size. Parathion, benzene hexachloride, aldrin, and dieldrin applied as spray emulsions were also more effective than when applied as dusts. Parathion and compound 497 were more toxic than the other compounds. Dieldrin exhibited better residual toxicity than parathion. A low dosage of 0.1 pound per acre gave complete control of young hoppers for a period of 14 days.

SUMMARY.—Varying dosages of benzene hexachloride, parathion, lindane, chlordane and toxaphene were applied as spray emulsions to evaluate their toxicity as contact poisons. Benzene hexachloride and parathion proved more effective as contact poisons than either chlordan or toxaphene. The benzene hexachloride was about twice as toxic as lindane. Apparently isomers other than the gamma contributed to the toxicity of benzene hexachloride. The contact action of the materials applied as spray emulsions was greater than when the materials were applied as dusts.

The materials applied as sprays made from wettable powders were as effective

as when applied as spray emulsions made from miscible oil concentrates. However, the dosages required to kill adults were considerably higher than those required to kill the first and second instar nymphs.

In the field tests chlordane and toxaphene were approximately equal in toxicity to young grasshoppers when applied as spray emulsions. All the materials were more effective when applied as spray emulsions than when applied as dusts. Parathion and dieldrin were more toxic to grasshopper nymphs than benzene hexachloride, chlordane, aldrin or toxaphene. Dieldrin exhibited better residual toxicity than parathion.

LITERATURE CITED

Bliss, C. I. 1938. The Determination of the Dosage-Mortality Curve from Small Numbers. Quart. Jour. of Phar. and Pharmacology. 11(2): 192.

Gaines, J. C., and H. A. Dean. 1948. Comparison of Insecticide Dusts for Grasshopper Control JOUR. ECON. ENT. 41(6): 945.

The Common Dry-Wood Termite as a Pest[1]

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The dry-wood termite *Kalotermes minor* Hagen is known to occur as far north as Tacoma, Washington, but its primary range extends from Mendocino County, California, to the southern tip of Lower California, Mexico. In northern and central California its activity is limited to a narrow coastal strip but in southern California it extends to the Colorado River where it overlaps the westerly range of *Kalotermes hubbardi*. At the southerly end of its range it extends into the territory of another species, *K. marginipennis* which inhabits the higher regions of Mexico.

Although this is a native species its economic status was rather insignificant prior to 1934 when the report of the Termite Investigation Committee was published. This report brings out the interesting fact that as recently as 1934 the common dry-wood termite was only a secondary pest of buildings. The late Professor Light stated "In the sporadic cases of attack on buildings it is most commonly found in window frames, door and window jambs, door sills and in rafters and sheathing. At that time its attacks on utility poles seemed of greatest commercial concern, an entire chapter having been written on the prevention and repair of termite damage to power, telegraph and telephone poles.

Since termite control is a comparatively young industry there is not a great amount of data available to guide its activities but some records of early work have been made available from the office of the County Agricultural Commissioner of Los Angeles County. During a 2-year period beginning with September, 1929 there were 3000 cases of termite damage reported. Of these, 2900 were caused by *Reticulitermes hesperus* while only 100 were the work of *Kalotermes minor*. Although we can not make a similar comparison at the present time a rough analysis of the work of my own small company during 1948 shows that in a total of 186 individual buildings which were treated for the control of various wood-destroying organisms, only 43 failed to include some dry-wood termite control work. In other words, the control of *Kalotermes* was necessary in 75 per cent of all the buildings treated by the company in 1948. Considering that only 3 per cent of the cases recorded in 1931 indicated damage by this species, its present status seems highly significant. It is true that my experience has been confined largely to the Whittier area but other operators in widely separated districts hav also observed this increased infestation by the dry-wood species. I do not believe that this increase is cyclic but, rather, that it is a continuous development aided and furthered by the activities of man. This is a type of increase of considerable importance to home owners here in the Southwest. It is the purpose of this paper to call attention to *Kalotermes minor* as an increasingly important pest in Southern California, to describe it

[1] Pacific Slope Branch Program.

briefly, to point out factors which may have contributed to its increase and to provide a discussion of present and future control measures.

Kalotermes minor is strictly an inhabitant of dry, sound wood. All the individuals in a colony except the mature reproductive forms and the soldiers are nymphs in various stages of development. These nymphs take the place of the worker caste found in colonies of the western subterranean termite. They are intermediate in size between the large dampwood termite *Zootermopsis angusticollis* and the smaller subterranean form referred to above. The nymphs vary in color from opaque white in the first and second instars to ivory and cream in the fifth and sixth instars. There is a dorsal median mark the full length of the abdomen and the older nymphs often appear to have a dorsal chevron-like marking at or near the middle of the abdomen. The soldiers have reddish-brown heads, black mandibles, unevenly toothed, and brownish bodies shading to dirty yellow toward the posterior end, thus differing from both the subterranean and the damp wood species. The head of the nymph is no wider than the body and is broadly attached to the thorax. The mature alate or winged reproductive form has a reddish-brown head and thorax and a black abdomen and gray wings. The wings are iridescent when struck by a beam of sunlight. Their hard ridged fecal pellets are distinctive and help to identify the species. These pellets are about a millimeter in length and are generally ivory colored but may vary through the reds and browns or may even appear to be black.

Except for cases where they are built into a house by the use of infested timber the dry-wood alates make contact with a structure while they are on the wing. This is in marked contrast to the subterranean termites which enter buildings almost entirely through the earth by way of exploration tunnels. Dry-wood termites swarm at mid-day when the weather is warm and clear. In most districts the peak of the swarming season is late in September or in October but it may commence as early as June and continue until December. According to Harvey[2] the alates crawl out of the emergence holes in groups of about a dozen, flutter upward with the prevailing wind to an altitude of from 60 to 70 feet, level off and gradually drift downward, reaching a spot possibly several hundred feet from the place of emergence. There are always some weak fliers which mate, shed their wings, and attack wood not far from the original colony. It was Harvey's observation that, although they often land on wood-shingle roofs they seldom enter the cracks and crevices in the shingles but seem to prefer to crawl under the eaves and enter the wood through joints between rafters and sheathing, or junctures between rafters and ridge or studding and plates. Other typical places of entry are mortises in window sashes, cracks between sashes and frames, under casings, or even through checks in knots ,which may occur in siding or the eave extension of rafters.

Although the reaction of the termites is phototropic in the early hours of the swarming flight there is a definite reversal which causes a negative response soon after mating. They then seek darkness. The fact that these alates often collect on the window sills may be due in part to the light reflected from the window panes during the period of positive phototropism.

When the males and the queens first bore into wood a residual frass made up of fine particles of the wood is deposited at the point of entry. This frass enables an alert inspector to locate newly established colonies. When these individuals have hollowed out an oblong or pear-shaped cell of sufficient size they both enter it and cement up the entrance hole with a brownish plug made of secretions and wood fragments. According to Harvey these termites now become inactive and sometimes the period of inactivity may continue for as long as nine months. When the dormant period ends, activity is resumed and by the end of the first year there may be as many as 20 nymphs and one soldier in the colony. At the end of the second year there may be 40 nymphs but there will still be only one soldier. The end of the third year finds the colony made up of as many as 165 individuals, all nymphs except 5 or 6 soldiers and the original parent forms. Alates are seldom seen until the fourth year.

[2] P. A. Harvey: Field Biologist, University of California, Berkeley.

Dry-wood termites are general feeders but they seem to prefer the sappy or spring-growth wood. Unlike the subterranean termites, they attack redwood freely. Piles of new lumber and new houses, in the framing stage, seem to be especially attractive to this species. In addition to structural timbers in general, they often attack English walnut, eucalyptus and citrus trees, gaining entrance through injuries or sunburned areas. Infestations have been found in apricot, avocado, alder, almond, cherry, California laurel, Monterey cypress, oak, peach, pear, plum, sycamore, willow and a number of other trees and shrubs.

Heavy infestations of *Kalotermes minor* may cause considerable structural weakness in timbering but collapse of buildings is uncommon except with the help of powerful external forces such as explosions or earthquakes. This was evident in Long Beach homes damaged in the earthquake of 1933. Structural collapse has occurred in oil derricks, wood-supported water tanks, decorative steeples, roof supports, wooden foot-bridges, utility poles and their cross-arms. In addition to the actual damage to structures there is a psychological effect on the home owner from the knowledge that his home is being attacked by insects. Furniture in an infested house may be damaged, the finish floor attacked, rugs cut by tunnels through infested flooring and even swinging doors have been colonized by the termites. General knowledge of termites has been promoted by the so-called termite clearance required by both government and private loaning agencies.

Some of the factors which may account in part for the present noticeable increase in infestation by dry-wood termites are:

Close proximity of homes caused by the general acceleration in residence construction in recent years;

Lack of knowledge of means of prevention due to the fact that national building codes and termite specifications have stressed the prevention of infestation by subterranean termites but have not given information on prevention of the dry-wood species;

The extensive practice of subdividing orchards into home sites leaving a few trees which may serve as foci of infestation;

Inadequate protection of piled lumber in lumber yards during the season of termite flights;

The use of the poorer grades of lumber necessitated by the general shortage of building materials in recent years;

Lack of vigilance on the part of both the layman and the termite operators which has delayed the discovery of the infestations and employment of inadequate control methods after the termites were known to be present; and,

The presence of numbers of heavily infested utility poles throughout the older residence districts.

Recent inspections of extensive housing projects has shown the presence of incipient infestations in many houses not more than a year old in attic areas and window sashes. During the past 4 or 5 years we have received many calls from home-builders during the swarming seasons of the dry-wood termites. Recent educational activities of many agencies have done much to enable the home-owners to recognize the termites but have not done much in the way of prevention and control of the pests.

Until recently control methods have remained fairly stationary. The insertion of Paris green as a dust into holes drilled in infested timbers has been general practice since the publication of the California Experiment Station Circular 318 in which the practice was recommended. This method takes advantage of the grooming habit of the termites to effect the ultimate elimination of the colonies. There has been some development in applicators and dusts since that time but otherwise the method has remained relatively unaltered. The invention of a high pressure dust gun has been considered by some as a definite advance in the dust-control method.

The injection of volatile liquid fumigants has been practiced successfully but the method has not yet been proven to be either more effective or less expensive than the powder insertion method.

The removal of all infested wood is a good practice if the infestation is limited to a small area and does not entail a large amount of carpentry or redecoration.

Fumigation has been the most recent advance in the control of *Kalotermes minor*. When fumigation is used for frame siding buildings the entire structure is encased in a gas-tight membrane; in frame-stucco construction the covering is limited to all exterior wood surfaces. The membrane may consist of three-ply gas-tight kraft paper or of rubberized tarpaulins. Both hydrocyanic acid and methyl bromide have been used in the fumigations and both have given good results. The dosage with either gas ranges from 2.5 to 3

pounds per 1000 cubic feet of space and the exposure period ranges from 18 to 48 hours. The type and size of the structure and the sealing problems involved are the primary factors determining the cost of the termite fumigation.

One of the big advantages of fumigation over other control measures is that the gas can be made to penetrate to otherwise inaccessible spaces. The fact that fumigations control other household pests and do not entail extra expense for structural repairs are additional advantages for the method. In the opinion of the writer the many advantages of fumigation over other control measures more than offset the fact that the fumigants have no residual effect which will reduce the probability of reinfestation. Removal of nearby sources of infestation is advocated. The lack of controlled flight by the winged reproductive castes is still another factor which reduces the danger of new infestations. Some operators have treated attic surfaces with repellents in the hope of deterring new infestations.

Many authorities consider the prevention of infestation by dry-wood termites to be practically impossible. Sealing *all* external openings in and between timbers in a house would be difficult and the cost of the operation would be great. Building the structure from pressure-treated wood might give permanent protection and the possibility of persistent odors from the chemical used for treatment would be limiting factors in the use of the method. A number of enterprising pest control operators are carrying on limited tests with some of the new synthetic organic insecticides having residual action in the hope that they may be of value in preventing infestations. The work of Wolcott (1949) in Puerto Rico with *Cryptotermes brevis* indicates that there are a number of chemicals having definite value in the prevention of infestations of dry-wood termites. The writer feels that "prevention" of dry-wood termite attacks is a fertile field for extensive investigation. This problem may be attacked from a number of hitherto untried angles but it will be a full-time undertaking and the results can not be determined in a limited period. It is hoped that governmental agencies will recognize the need for scientific investigation of methods of prevention of infestations by *Kalotermes minor*. This is a problem of vital importance to every home owner in the Pacific Southwest and it should be given immediate consideration.

LITERATURE CITED

Wolcott, G. N. 1949. The most effective termite repellents. JOUR. ECON. ENT. **42**(2): 273–5.

SECRETION OF LIQUID BY A LEAFHOPPER

Most entomologists are aware that certain insects secrete a considerable amount of liquid. This becomes quite evident to those who happen to park their cars under trees infested with aphids; however there are not so many that are aware of the tremendous amount of liquid which can be secreted by some of the leafhoppers.

On June 19, 1949, a nymph of *Oncometopia undata* was observed on a century plant. It was also noted that little puddles of "water" were appearing on the window sill. After watching the nymph, it was soon obvious that it was responsible for the puddles of water, therefore a one dram vial was placed in the proper location and 2.6 cc of liquid were collected in a period of approximately 12 hours. The liquid was clear and tasteless.

CLYDE F. SMITH

Permanence of DDT in Powder-Post Beetle Control in Bamboo

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In a previous report (Plank 1947) it was shown that DDT was outstanding in control of the bamboo powder-post beetle *Dinoderus minutus* (F.), a serious cosmopolitan pest of harvested bamboo. A single, brushed application of a 5-per cent solution in kerosene maintained 94 per cent of the internodes of highly susceptible culms free from infestation for 10 weeks.

With the object of testing the lasting qualities of this insecticide against the same insect, a larger experiment was carried out in which DDT was used at the same strength as formerly, but was dissolved in diesel fuel oil having a specific gravity of 0.834 at 27° C. In addition to freshly harvested 1-year-old culms of *Bambusa vulgaris* Schrad. ex Wendl., as used before, culms of the same age and species that had been clump-cured for 35 days by methods previously described (Plank 1939) were used to note the effect of previous drying on residual control. Ten culms of each kind from separate clumps were submerged for 10 minutes in the DDT solution and in the solvent alone in horizontal, galvanized-iron tanks. These tanks were of sufficient size to accommodate the full length of the pieces dipped so that they could be covered with about 3 inches of solution. A set of culms harvested from the same clumps served as untreated controls.

METHODS.—Immediately before treatment, on the day following harvest, each culm was cut into 3 adjacent sections of 10 internodes each, counting from the base of the culm. These sections varied from 8 to 14 feet in length and from 2 to 3.75 inches in outside diameter. Three-quarter-inch sample rings taken from the internode next to the lower end of each section at time of treatment showed the average moisture content of the freshly harvested culms to be 71.9 per cent and of the clump-cured 48.1 per cent, based on the oven-dry weight of the wood (Markwardt & Wilson 1935). After treatment, all sections were placed in rotation in a horizontal drying rack sheltered from the weather. They were arranged so that no treatment from any one culm was directly above or below the same treatment from the preceding or succeeding culms, and that all were equally exposed to beetles emerging from nearby infested bamboo.

Fifty gallons of dipping solution containing approximately 5 per cent of DDT by weight was made by dissolving 17.5 pounds of DDT in 48.5 gallons of oil. About 0.20 gallon of this solution was required to treat the three 10-internode sections of an average culm. Loss of the "wet" appearance of the DDT-treated pieces required about 4.5 hours on the green sections and about 3 hours on the clump-cured sections.

External examination of all sections was made every 3 months for 1 year after treatment, care being taken not to rub off any more of the DDT residue than could be avoided. Any internodes found with one or more holes deeper than the average length of the beetle (about 0.1 inch or 3 mm.) were counted as infested. Entrances at a bud, branch-trimmed node, or bud-sheath scar that penetrated more than 0.5 inch were considered infestations in the corresponding internode. At the last examination the culm sections were split open and the internodal infestation determined from internal as well as external evidences. The results of these examinations are shown in table 1.

RESULTS.—It will be noted that the Diesel fuel oil solvent alone produced a small amount of control significant only during the first 6 months after application on clump-cured material. On the other hand, the 5-per cent solution of DDT in this solvent afforded a highly significant degree of protection that lasted for 12 months on both freshly harvested and clump-cured material. This control tended to be more permanent on the former than on the latter, but at no examination was the difference in external evidences of internodal infestation statistically significant between the green and partly dried bamboo.

When split open at the 12-month examination all of the 300 internodes in the

Table 1.—Control of bamboo powder-post beetle infestation in 1-year-old culms of Bambusa vulgaris at end of specified periods after submergence for 10 minutes in a 5-per cent solution of DDT in diesel fuel oil.

Treatment	Freshly Harvested Culms		Clump-Cured Culms	
	Internodes Infested[1]	Control	Internodes Infested[1]	Control
	Number	*Per Cent*	*Number*	*Per Cent*
At 3 months after treatment				
Untreated	208	0	225	0
Diesel fuel oil, alone	214	0	184	18.2
DDT, 5 per cent in diesel fuel oil	4	98.1	4	98.2
L.S.D. at 5 per cent level	33	—	33	—
L.S.D. at 1 per cent level	44	—	44	—
At 6 months after treatment				
Untreated	271	0	272	0
Diesel fuel oil, alone	252	7.0	237	12.9
DDT, 5 per cent in diesel fuel oil	11	96.0	16	94.1
L.S.D. at 5 per cent level	30	—	30	—
L.S.D. at 1 per cent level	39	—	39	—
At 9 months after treatment				
Untreated	278	0	290	0
Diesel fuel oil, alone	272	2.2	267	7.9
DDT, 5 per cent in diesel fuel oil	18	93.5	24	91.7
L.S.D. at 5 per cent level	26	—	26	—
L.S.D. at 1 per cent level	34	—	34	—
At 12 months after treatment				
Untreated	279	0	290	0
Diesel fuel oil, alone	275	1.4	275	5.2
DDT, 5 per cent in diesel fuel oil	25	91.0	36	87.6
L.S.D. at 5 per cent level	28	—	28	—
L.S.D. at 1 per cent level	37	—	37	—
At 12 months after treatment[2]				
Untreated	300	0	295	0
Diesel fuel oil, alone	287	4.3	286	3.1
DDT, 5 per cent in diesel fuel oil	27	91.0	61	79.3
L.S.D. at 5 per cent level	30	—	30	—
L.S.D. at 1 per cent level	40	—	40	—

[1] In three 10-internode sections from each of 10 culms per treatment; these culms were harvested from separate clumps and, immediately before treatment, cut into adjacent sections, beginning at the base.
[2] Total infestation from internal as well as external evidence.

untreated freshly harvested sections and all but 5 in the untreated clump-cured sections were found to be attacked by the beetle. Most of the former were riddled, whereas those that had been clump-cured were lightly damaged. Where DDT was applied, the control was 91 per cent in the freshly harvested culms and 79 per cent in the clump-cured culms, with the difference in number of damaged internodes being statistically significant. Most of the damage, particularly in the clump-cured culms, was caused by the longitudinal scoring of the inside surface of the internodes by the beetles, some of which entered through cracks that developed in the rind, but the majority of such pieces would still be considered serviceable for certain purposes. Apparently no improvement in control of internodal infestation

is to be derived from previously drying the culms, as in clump-curing, before dipping in DDT.

In contrast to the white, even, fine-grained crystallization produced from the kerosene solution previously used, that from DDT in fuel oil was nearly translucent and tended to form slender, branching threads having the general appearance of fine tree roots. However, like the DDT-kerosene residue it left no stain and did not appear to affect the quality of the wood. This residue, which was less easily dislodged by rubbing or brushing, was visible on most of the culm sections 3 months after treatment and persisted on some for 9 months more. It was particularly persistent on the sections that had been dipped green; six of the green sections bore visible residue at 12 months after treatment, as compared with only one of the clump-cured sections. This difference in ability to hold a persistent residue was an important factor in the protection of the freshly harvested culms. Apparently, as suggested by the shorter drying time recorded, the partially dry surface of the clump-cured culms absorbed more of the solution and consequently left a smaller amount for residue formation on the outside than did the green surface of the freshly harvested culms.

Ring samples similar to those used for moisture determinations were taken from both kinds of bamboo before treatment and dipped in the same solution. These samples had a minimum proportion of outside culm surface to cut-and-inside surface and therefore had opportunity to become thoroughly saturated with the DDT solution. Under continuous exposure in a room where numerous beetles were always present, they have remained uninfested for 24 months after treatment. Cage tests have shown the residue still to be sufficiently toxic to kill all beetles exposed to its effects for periods of 4 days or longer.

It is evident from the foregoing that much, if not all, of the internal damage found in the previously mentioned green and clump-cured sections that were dipped whole could have been prevented by first splitting the culms so that the DDT solution could cover the inside as well as the outside of the culm wall. Breaking out the septa, or partitions at the culm nodes, would accomplish the same purpose where split bamboo is not desired. Small lots of commercial bamboo handled in both ways and retreated after shaping for use have remained free of infestation by all wood-boring insects, including the bamboo powder-post beetle, during nearly 30 months of service.

SUMMARY.—Green and partly dried sections of bamboo culms were dipped whole for 10 minutes in a 5-per cent solution of DDT in fuel oil and in the solvent alone. The solvent alone gave a small amount of protection against internodal infestation by the bamboo powder-post beetle, but this protection was significant only during the first 6 months after application on partly dried material. The 5-per cent DDT solution produced a highly significant degree of control that lasted for 12 months on both green and partly dried bamboo, but such protection was more permanent on the green culms. Formation of a more persistent film of residue on the surface on the green culms was an important factor in their protection. Pieces of bamboo dipped separately in the same solution bore a residue that was toxic to the bamboo powder-post beetle for 24 months, and small commercial lots have remained free of infestation by this and all other wood-boring insects during nearly 30 months of service.

LITERATURE CITED

Markwardt, L. J., and T. R. C. Wilson. 1935. Strength and related properties of woods grown in the United States. U. S. Dept. Agr. Tech. Bul. **479**:7.

Plank, H. K. 1939. Investigations of the powder-post beetle in bamboo. Puerto Rico (Mayaguez) Fed. Expt. Sta. Rpt. 1938: 115.

Plank, H. K. 1947. DDT for powder-post beetle control in bamboo. Sci. **106**(2753): 317.

Deposit and Residue of Recent Insecticides Resulting from Various Control Practices in California[1]

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The widespread use of several new chemicals for control of insect pests has raised questons concerning their possible harmful effects upon consumers of treated foods. The two factors concerned in this problem are the intrinsic toxic action of the various chemicals, especially after long continued exposure, and the amounts remaining upon or within treated plants or animals when these are used as food. The first point is being investigated in various pharmacological laboratories such as those of the federal Public Health Service and the Food and Drug Administration, but the second can be made clear only by analysis of produce treated in practical pest control programs. The various field men of the Division of Entomology and Parasitology of the University of California at Berkeley apply the new materials in their experimental work as quickly as they become available and a large number of analyses of the amounts present during the growing season and at harvest have been made in the insect toxicology laboratory. The purpose of this report is to present pertinent data on the deposit and persistence of those new insecticidal chemicals which have been tested under conditions of practical use. The method of application, dosage and date are given in each case and since loss of deposit by weathering, volatilization and other processes is strongly affected by time, the interval from last application to analysis is shown also. The results in some cases are for individual tests but when several analyses corresponding to identical treatments were in close agreement, only an average is given.

Methods of Analysis.—Treatment of the samples in preparation for analysis was as follows except as noted in the tables. Enough material, as received from the field, was taken to fill a one gallon glass jar half-full and chemically pure benzene was added until about 100 ml free liquid was present. After 5 minutes rolling and shaking, the liquid was allowed to drain out and was measured. A portion, usually 25 or 50 ml, was taken for analysis. The assumption was made that the insecticide was uniformly distributed in the recovered and non-recovered benzene, so the total residue could be calculated from that found in the portion analyzed. The residue so determined may be called the surface contamination as distinguished from that within the fruit or other produce. With processed foods, vegetables grown on treated soils and with animal products, total contamination was determined by intimately mixing the finely subdivided sample with solvent in a Waring blendor. These are indicated in the tables.

Analysis for DDT and related compounds was made by the colorimetric method of Schechter *et al.* (1945). In some early tests use was made of the total chlorine method, which gives practically identical results (Reiber & Stafford 1946). A micro-bioassay method developed in the insect toxicology laboratory was used for determination of γ benzene hexachloride with houseflies as test organisms (Hoskins & Messenger 1950[2]). Hence the residue is expressed as γ isomer which gave the same mortality. For convenience, this value is referred to as "γ equivalent."

It is not possible to state definite limits of accuracy for the analyses. The usual errors in sampling were involved though all samples were taken by experienced field entomologists. The completeness of extraction of residual insecticide was studied in several cases with the general result that the additional recovery in a second portion of solvent was only a very few per cent of that in the first portion. This was confirmed by tests for recovery of added insecticide. As a semiquantitative measure of the *reproducibility* of the sampling and analytical procedures it may

Paid Paper.

[1] The various samples which were analyzed for residue came from field experiments of the following members of the staff of the Division of Entomology and Parasitology: O. G. Bacon, A. D. Borden, D. P. Furman, H. W. Lange, A. E. Michelbacher, L. M. Smith, R. F. Smith, and E. M. Stafford, and from the following cooperators: R. H. Sciaroni, Asst. Agriculturist, San Mateo County; J. S. Simon, Director Technical Department Dried Fruit Association of California and R. M. Warner, Research Director, California Fig Institute. The following made the chemical analyses: W. R. Erwin, O. H. Fullmer, P. S. Messenger and J. M. Witt. Grateful acknowledgement is hereby made for the assistance of all who collaborated in the work.

[2] In press.

Table 1.—Residues of DDT, dichlorodiphenyl dichloroethane or methoxychlor.

CROP	METHOD OF USE	NUMBER OF APPLICATIONS	ACTIVE INGREDIENT PER APPLICATION[1]	DATE OF APPLICATIONS	INTERVAL IN DAYS[2]	ppm	
			A. DDT				
Apples (Gravenstein)	Spray[3]	1	0.75	May 2 (Parathion spray on June 6)	98	0.5	
		2	0.5; 0.5	May 26; June 20	23	3.9	
		2	1.0; 0.75	May 10; June 20	23	3.6	
		3	1.0; 1.0; 0.5	?; ?; June 24	40	2.5	
Apricots (Blenheim)	Spray[3]	1	0.75	May 6	0	21.0*	
					81	<0.1	
		1	0.75	May 13	0	22.8*	
					48	3.1	
		2	0.75	Apr. 1; May 6	0	30.5*	
					81	<0.1	
		2	0.75	Apr. 17; May 10	60	3.3	
		1	0.75	Apr. 5	38	6.3	After drying
					93	0.4[5]	2.8[5]
		1	0.75	May 4	0	18.9*	
					64	0.6[5]	4.6[5]
		1	0.75	June 2	36	0.8	2.6[5]
		3	0.75	Apr. 5; May 4, June 2	36	3.6	11.8[5]
	5% dust	1	2/acre	May 9	0	1.6*	
					52	0.3	
Corn (Golden Cross)	hand application[6]	1	0.0036 grams/ear	Aug. 15	22	17 (husks)	
						2.1 (ears)[7]	
	10% dust	3	3.5/acre	Aug. 5, Aug. 15, Aug. 24	21	32 (husks)	
						0.0 (ears)[7]	
Grapes (Emperor)	5% dust (50% S)	1	1/acre	May 10	147	0	
		1	1/acre	July 18	80	0.4	
		2	1/acre; 0.5 acre	May 10, Aug. 6	59	0.7	
Olives (Mission)	Spray[3] (plus 1 gal. kerosene)	1	0.6	June 11	2	20.5[4]*	
		2	0.5	June 4; June 19	0	35.6[4]*	
		2	0.5	June 4; June 27	1	25.4[4]*	
(Sevillano)		1	1.0	July 15	13	46.5[4]*	processed
					93		3.4[4]
Peaches (Phillips)	5% dust)	2	1.7/acre	July 20; Aug. 15	26	2.1	
Pears (Bartlett)	Spray[3]	1	1	July 30	8	4.2	
		1	0.5[8]	July 21	4	3.5	
		2	0.5[8]; 0.25[8] (1 qt. oil in second spray)	?; June 16	31	5.7	
		3	1.0; 1.0; 0.67	Apr. 20, Apr. 30, May 30	49	5.1	
		4	1.0	?; ?; ?; May 21	19	10.2*	
					40	3.7	
		4	1.0 (1 gal. oil in last spray)	?; ?; ?; May 21	19	9.7*	
					40	0.8	
		4	0.5; 0.5; 0.25, 0.35[8]	Apr. 20, May 19 June 10, July 11	8	7.1	
	Spray from Speed Sprayer[9]	3	3/acre	Apr. 2; Apr. 16 May 2	0	10.0*	
					60	0.9	
	Spray[3]	1	1 (13.5/acre)	Apr. 4			
	5% dust	2	5/acre	Apr. 22; May 8	54	0.3	
	same, dust contained 2% oil				54	0.7	
	same, dust contained 4% fatty acid derivative				54	0.9	
	same, dust contained 4% bacotom adhesive				54	1.1	
	Spray[3]	1	1 (13.5/acre)	Apr. 4			
	5% dust	2	10/acre	Apr. 22, May 8	54	0.5	
	same, dust contained 2% oil				54	0.7	
	same, dust contained 4% fatty acid derivative				54	0.8	
	same, dust contained 4% bacotom adhesive				54	2.3	
Pears (Winter Nelis)	Spray[3]	1	1	Aug. 9	5	11.5*	
					34	3.0	
		1	1	Sept. 10	3	11.0*	
					22	3.1	
Prunes (French)	Spray[3]	1	1	June 16	79	0.7	
							After drying
		2	1	Apr. 20; June 16	79	1.0	2.1
Raisins	Spray[10]	1		?	30	0.5	
Tomatoes (Pearson)	Spray[3]	1	1.5/acre	June 13	4	1.4*	
					13	0.3*	
		1	1.5/acre	July 3	3	1.1*	
	50% dust	1	1.5/acre	June 13	3	0.8*	
					12	0.2*	

Table 1.—*cont.*

Crop	Method of Use	Number of Applications	Active Ingredient per Application[1]	Date of Applications	Interval in Days[2]	ppm	
B. Dichlorodiphenyl dichloroethane							
Apples (Gravenstein)	Spray[3]	2	1.0	May 2; June 6	63	1.8	
Apricots (Blenheim)	Spray[3]	2	1.0	Apr. 1; May 6	0	38.5*	
					81	3.7	
	Spray[4]	2	1.0	Apr. 5; May 4	9	17.1*	After drying
					64	0.3	7.1[4]
Prunes (French)							After drying
	Spray[3]	2	1.0	Apr. 20; June 16	79	0.92	1.51
		2	1.0 (1.7/acre)	Apr. 20; June 14	68	0.68	0.7[4]
	5% dust	2	2/acre	Apr. 20; June 14	68	0.14 0.38	0.3[4]
Tomatoes (Pearson)							
	Spray[3]	1	1.5/acre	July 30	3	1.42	
	5% dust	1	1.5/acre	June 14	12	0.15*	
C. Methoxychlor							
Apples (Gravenstein)	Spray[3]	1	1.5	June 6	63	1.2	
		2	1.5	May 2; June 6	63	1.6	
Apricots (Blenheim)							After drying
	Spray[3]	1	1.5	May 4	64		2.2[4]
		2	1.5	Apr. 5; May 4	0	32.4*	After drying
					64	0.18	1.8[4]

* Not ripe at time of sampling.
[1] In pounds per 100 gallons of spray, except as noted otherwise.
[2] Days from last application to time of sampling.
[3] 50% wettable powder except as noted otherwise.
[4] Finely ground and thoroughly extracted.
[5] Pureed and canned.
[6] Approximately 0.35 cc of 1% solution in light mineral oil applied to top of each ear.
[7] Whole ear, not trimmed for market.
[8] Plus 4 pounds lead arsenate.
[9] 0.6 gallon of 36% solution in 100 gallons of spray.
[10] 1 per cent aqueous suspension of 50% wettable powder sprayed on outside of lug box to incipient run off.

be said that results on duplicate samples almost always agreed to within less than 25 per cent in case of the larger residues and often within a very few per cent. Agreement was much poorer with the low residues and these results in general only indicate the order of magnitude.

DISCUSSION.—A number of results, corresponding to completely useless treatments, have not been included in the tables, but it has seemed worth while to include those which, though fairly satisfactory, have been succeeded by better control programs. The high contaminations of alfalfa resulting from unnecessarily heavy applications of DDT and dichlorodiphenyl dichloroethane are examples of this point.

With all fruits tested, DDT residue was well below 7 ppm one month after application and in most cases below 5 ppm. Dusts gave much lower deposits. Limited results with dichlorodiphenyl dichloroethane and methoxychlor indicated similar situations. Dried fruits may contain considerable DDT or dichlorodiphenyl dichloroethane except in case of prunes in which case the lye treatment probably destroys the chemicals. Data for apricots sprayed with basic lead arsenate (not given in table 1) show 5.4 ppm As_2O_3 81 days after application. This would result in heavy contamination in dried fruit. Much arsenic was removed from prunes during the drying treatment, *e.g.*, 1.2 ppm dropped to 0.3 ppm. Considerable data on residues of chlordan on pears (obtained by the total chloride method) are not included in the tables. Two and three applications of 2 to 6 pounds per 100 gallons spray for control of codling moth resulted in 8 to 16 ppm at harvest a month later. This material seems to be deposited more heavily than DDT and to be fairly persistent. Olives take up much DDT and considerable comes through the processing treatment.

The contamination of raisins stored for one month in boxes treated with DDT on the outside only was unexpected, since it indicated that this substance could spread by volatilizing. A more precise experiment was set up in which a small amount of powdered DDT was placed on the inside bottom of quart mason jars and racks 1 inch high made of heavy screen were set over it. Raisins were then added to fill the

Table 2.—Residues of parathion.

CROP	METHOD OF USE	NUMBER OF APPLICATIONS	ACTIVE INGREDIENT PER APPLICATION[1]	DATE OF APPLICATIONS	INTERVAL IN DAYS[2]	ppm	
Apples (Gravenstein)							
	Spray[3] (15)	1	0.23	June 6	63	0.07	
		2	0.23	May 2; June 6	63	0.03	
Apricots (Blenheim)							
	Spray[3] (15)	2	0.45	Apr. 1; May 6	0	5.0*	
					81	0.02	
							After drying
	Spray[3] (25)	2	0.75	May 4; June 2	23	0.13	0[4]
		2					
Artichokes	2% dust	1	0.4/acre	Aug. 22 (no fruit set)	36	0	
		1	0.4/acre	Sept. 10 (fruit well developed)	17	0.22	
		1	3/acre	Aug. 14 (no fruit set)	58	0.03	
Figs (Calmyrna)							
	2% dust	2	2.4 and 2/acre	June 30; Aug. 3	7	0.06*	After drying
					27	0.02	0[4]
		2	1.9 and 1.2/acre	June 30; Aug. 3	7	0.04*	After drying
					27	0.01	0[4]
Grapes (Zinfandel)							
	1% dust	1	0.8/acre	June 23	7	0.5*	
					17	0.04*	
					27	0.03*	
		1	0.4/acre	May 26	45	0.04*	
	2% dust	1	1.6/acre	Aug. 4	7	2.5*	
					14	0.23*	
					37	0.07	
	4% dust	1	3.2/acre	Aug. 4	7	4.2*	
					14	0.36*	
					37	0.10	
	Spray[3] (15)	1	3/acre	June 29	21	0.16*	
	Spray[3] (25)	1	2.5/acre	May 25	46	0.4*	
		1	2.5/acre	Aug. 3	8	3.3*	
					15	1.07*	
					38	0.12	
		1	5/acre	Aug. 3	8	6.9*	
					15	3.2*	
					38	0.34	
Olives (Mission)							
	Spray[3] (25) (plus 1.5% medium oil)	1	0.5	Aug. 26	8	1.10[4]*	
	Spray[3] (25)	1	0.6	Sept. 9	48	0.03[4]	Processed
					104		0[4]
—(Sevillano)	Spray[3] (25)	1	0.5	June 5	5	5.1[4]*	
					123	0.01[4]	
					160		0[4]
—(Nevadillo)							
	Spray[3] (25)	1	0.6	Sept. 1	46	0.25	
—(Manzanillo)							
	Spray[3] (25)	1	0.6	Sept. 1	46	0.07	
		1	0.6	June 24	118	0.02[4]	
					181		0[4]
Peaches (Peak)							
	Spray[3] (25)	1	4.2/acre	Aug. 24	8	0.49	
		1	5.5/acre	Aug. 24	16	0.39	
	2% dust	1	1.2/acre	Aug. 24	8	0.06	
					16	0.02	
Pears (Bosc)							
	Spray[3] (15)	1	0.11	June 28	39	0.09	
Plums (Duarte)							
	Spray[3] (25)	1	0.6	June 3	98	0.01	
Prunes (French)							
	Spray[3] (25)	1	0.25	June 16	79	<0.01	
							After drying
		2	0.25	Apr. 20, June 16	79	0.01	0.01[4]
		2	0.25 (0.42/acre)	Apr. 20, June 14	68	0.01	0[4]
	2% dust	2	0.72	Apr. 20, June 14	68	0.01	0[4]
Walnut meats							
	Spray[3] (25)	1	0.6	July 12	153	0[4]	

* Not ripe at time of sampling.
[1] In pounds per 100 gallons of spray, except as noted otherwise.
[2] Days from last application to analysis.
[3] Wettable powder of concentration shown in parentheses.
[4] Finely ground and thoroughly extracted.

jars. One jar was left open and the other closed tightly. Analyses after 1 month showed 1.67 ppm DDT for the closed jar and 2.55 ppm for the open one. Clearly, DDT had moved upward across the 1 inch gap and doubtless farther up among the raisins. The slight air movement due to changes in temperature from day to night would account for the greater contamination when the jar was open.

Table 3.—Residues resulting from application to soil.

Method of Use	Number of Applications	Active Ingredients in Pounds/Acre	Application Time	Interval (Months) To Harvest	Interval (Months) To Analysis[1]	ppm[2,3]
		Carrots				
A. BHC						
25% wettable powder disked into soil	1	1 lb. isomer 3.5 lb. other isomers	June, 1947	3	9	0.1
		2 lbs. isomer 7 lbs. other isomers	June, 1947	3	9	>0.6
		Corn (seed)				
25% wettable powder disked into soil	1	2 lbs. isomer 7 lbs. other isomers	June, 1947	3	9	0
		Corn Stalks				
	1	2 lbs. isomer 7 lbs. other isomers	June, 1947	3	9	0.3
		Potatoes (Irish)				
25% wettable powder disked into soil	1	1 lb. isomer 3.5 lbs. other isomers	June, 1947	3	9	0.27
	1	2 lbs. isomer 7 lbs. other isomers	June, 1947	3	9	0.3
		Sugar Beets				
25% wettable powder disked into soil	1	1 lb. isomer 3.5 lbs. other isomers	June, 1947	3	9	0.12
	1	2 lbs. isomer 7 lbs. other isomers	June, 1947	3	9	>.13
		Tomatoes				
25% wettable powder disked into soil	1	2 lbs. isomer 7 lbs. other isomers	June, 1947	3	9	0.1
		Cantaloupes, Carrots, Beans, Potatoes, Tomatoes				
B. DDT						
50% powder disked into soil	1	20	June, 4	growing season		0
	1	40	June, 4	growing season		0
		Potatoes				
C. Parathion						
25% powder disked into soil	1	0.45	May, 10		4	0.10
	1	0.75	May, 10		4	0.13
		Tomatoes				
25% powder disked into soil	1	0.75	May, 10		5	0.03

[1] Kept at 42° F. from harvest to analysis.
[2] With benzene hexachloride the residues are expressed as γ isomer corresponding to the mortality obtained in the biosasay; this is sometimes referred to as γ equivalent.
[3] All produce was finely subdivided and extracted in a Waring blendor.

Results which also showed the volatility of DDT were obtained by analysis of grain from elevators which had been treated with DDT when empty. Typical results were: barley from the center of a 72,000 bushel elevator which had been sprayed with 225 gallons of 0.5 per cent aqueous suspension of DDT contained 1.5 ppm. Similarly, 2.4 ppm DDT were found in wheat from the center of a 42,000 bushel elevator treated with the same amount of aqueous suspension. The grains had been in storage 3 to 4 months. In these cases the DDT had diffused several feet.

Parathion disappears rapidly and all dried or processed fruits were free from it except for an indication of a minute amount in one prune sample. Residues exceeding 1 ppm after a few days were found

Table 4.—Residues in animal feed and products. (One application.)

METHOD OF USE[1]	ACTIVE INGREDIENT PER APPLICATION	DATE OF APPLICATION	DAYS TO HARVEST	ppm
A. DDT on alfalfa				
0.5% dust	0.15/acre		23	0– 1.9
1% dust	0.25–0.30/acre		14–23	0– 3.1
2% dust	0.5–0.6		14–20	5.2– 7.9
3% dust	0.6–0.9		10–19	4.2– 8.7
4% dust	0.8–1.2		11–22	2.3– 9.8
5% dust	1.0–1.75		10–19	3.1–15.3
25% emulsible solution	1.0		9–18	36.4–47.2
ditto	0.5		10–23	3.7–26.0
ditto	0.25		10	7.1[2]
			20–175[7]	8.0[2]
B. DDD on alfalfa				
20% emulsible solution	1.0	July 25	9	40.8
1% dust	0.25/acre	Aug. 24	15	0.9
2% dust	0.56/acre	Aug. 24	15	2.8
C. Parathion on alfalfa				
1% dust	0.25	July 20	5	0.70
1% dust	0.3	July 20	5	0.44
			10	0.37
1% dust	0.25	Aug. 24	16	0
2% dust	0.4	June 18	5	1.8
25% wettable powder	0.3	July 13	12	0.1

FEED	RESIDUE IN FEED	PERIOD ON FEED	DAYS SINCE INTAKE CEASED	ppm
D. DDT in cows' milk				
Alfalfa hay (in bales)	8.0[2]	Nov. 21–Feb. 8 (79 days)	0	1.7–4.8 65 (butter)
One-half contaminated hay	4.0	Feb. 8–Mar. 2	0	1.0–2.8
Uncontaminated hay	0	Mar. 3	24	0.5
			25	12(butter)

APPLICATION	DAYS AFTER APPLICATION	ppm[4]
E. Benzene hexachloride in cows' cream[3]		
0.5 suspension of wettable powder sprayed	1	5.5
on cow to free run off	3	3.0
	5	1.51
	10	0
ditto, but licking prevented	2	3.2
	3	3.7
	4	1+
	7	1−
	8	0

APPLICATION[5]	EXPOSURE[6]	Skin ppm	Flesh ppm	Liver ppm
F. Benzene hexachloride in chicken tissues				
0.5% solution of γ isomer in light fuel	2	0.4	0	0
oil and kerosene	14	0	0	0
0.5% aqueous suspension of γ isomer in	2	0	0	0
technical benzene hexachloride (12% content)	14	0	0	0
2.4% aqueous suspension of above material	2	8.6	2.4	0.7
	14	2.9	0.3	0.4
	21	2.5	0.3	0.3
	42	0	0	0

[1] All applications to alfalfa made by airplane.
[2] Average of numerous determinations.
[3] Cream allowed to rise spontaneously for about 48 hours.
[4] As γ equivalent.
[5] Solution or suspension applied to wooden roosts to incipient runoff.
[6] Successive nights chickens used treated roosts to time when they were sacrificed.
[7] In bales.

Table 5.—Selenium residues.

Crop	Method of Application	No. of Applications	Active Ingredient per Application	Dates	Interval	ppm In Flesh	ppm In Whole Fruit	
Apples (Gravenstein)	Spray[1]	2	0.12 oz./tree	May 18, July 2	52	a) 0.33 b) 0.25 c) 0.27 d) 0.07 e) 0.26 f) 0.08	0.45 0.50 0.38 0.22 0.31 0.17	
	None					0.05	0.06	
Apples (Delicious)	Spray[2]	1		Aug. 2	60	0.03	0.18	0.03[3]
		2		July 16, Aug. 21	41	0.03	0.46	0.19[3]
	None					trace	trace	

Crop	Method of Application		No. of Applications	Period Since Application to Soil	ppm
	Grown on Contaminated Soil				
Wheat plants (5±inches tall)	Taken From Depth	Se Content ppm			
	0–1 foot	0.71[4]	5	1 to 3 years	0.43
	1–2 feet	0.61[4]	5	ditto	0.10
	2–3 feet	1.68[4]	5		0.12
	0–1 foot	0.10[5]	0		0
	2–3 feet	0.20[5]	0		0.57
	0–1 foot	0.17[6]	2	four months	0
	0–1 foot	0.09[7]	0		0.26

[1] One pint *Selocide* concentrate, containing 0.8 ounce Se per 100 gallons spray.
[2] One and one-half pints *Selocide* concentrate containing 1.2 ounce selenium per 100 gallons spray.
[3] Fruit washed in solution of 35 pounds sodium silicate per 100 gallons washwater at 90° F. followed by solution of 1 per cent hydrochloric acid at 86° F.
[4] Soil from beneath orange tree in southern California, sprayed with *Selocide* twice in 1945, once each in 1946, 1947 and 1948.
[5] Soil adjacent to that described in 4), but not exposed to *Selocide*.
[6] Soil from beneath apple tree in Contra Costa County, sprayed with *Selocide* May 18 and July 2.
[7] Soil adjacent to that described in 5), but not exposed to *Selocide*.

only with grapes and with olives and they rapidly decreased thereafter. The residues from this material may be measured only in fractions of a part per million from any practical spray program.

Addition of a crude lot of benzene hexachloride to the soil resulted in contamination of all five vegetables grown thereon, but the amounts were less than 1 ppm in all cases. Taste tests on the same plants showed good agreement with the bioassays. This work will be reported in detail elsewhere. The experiment with benzene hexachloride was made with crude material and the results may be no indication of what would happen with the modern purified gamma product, lindane. It is very significant that none of the four vegetables grown on soil containing large amounts of DDT absorbed any of it. This is in agreement with results from other states. An interesting proof that it is difficult to introduce DDT into the circulating fluid of plants came from analyses of bean plants to which the chemical was applied in various ways (Huffaker 1948). On the other hand, parathion is absorbed from the soil by potatoes (Table 2) and a slight positive result was obtained with tomatoes.

More complete accounts of most of the work covered in table 4 have been published elsewhere, *e.g.*, DDT on alfalfa (Smith *et al.* 1948) and DDT in cows' milk (Smith *et al.* 1948) benzene hexachloride in cows' cream (Furman & Hoskins 1948), benzene hexachloride in chicken flesh and organs (Furman 1949[1] & Bankowski). To facilitate comparison with other work, the more important results are included here.

The passage of DDT into the milk when cows, or other lactating animals, ingest

[1] See page 980.

the chemical has been reported several times. The results of Smith *et al.* (1948) were of special importance since the amounts of DDT ingested resulted from practical use of the chemical for control of alfalfa butterfly. The DDT in the milk amounted to 15 to 23 per cent of the intake in the feed. Since storage in body fat undoubtedly occurred also, the efficiency of absorption must be high.

Benzene hexachloride appears in cows' milk rapidly, in one case the maximum amount being found within 24 hours after spraying. Absorption is rapid with chickens also but tests were made too infrequently to determine the time for maximum content in the various tissues. The long interval, up to 42 days, for complete disappearance of the chemical is not a measure of its rate of elimination, for the birds used the same roosts each night and hence received successively smaller amounts of benzene hexachloride as it gradually disappeared from the roosts. It may be noted that taste tests failed to reveal any off flavor of the meat.

Extensive experiments on residues of selenium resulting from use of a proprietary insecticide,[1] were reported earlier (Hoskins *et al.* 1938). Interest in this subject has continued and recently analyses have been made of apples sprayed with the material and of young wheat grown on soil exposed to drippings from sprayed trees. These are shown in table 5. Young wheat is a good indicator of the selenium in soil available to cultivated plants.[2] The analytical results indicate that selenium from the spray material is not absorbable either following application or after a lapse of years.

[1] *Selocide.*
[2] Personal communication.

REFERENCES CITED

Averell, R. P., and M. V. Norris. 1948. Estimation of small amounts of O,O-diethyl-O, p-nitrophenyl thiophosphate. Analytical Chemistry **20**: 753–6.

Furman, D. P., and W. M. Hoskins. 1948. Benzene hexachloride in cream from cows' milk. JOUR. ECON. ENT. **41**: 106–7.

Hoskins, W. M., A. M. Boyce and J. F. Lamiman. 1938. The use of selenium in sprays for the control of mites on citrus and grapes. Hilgardia **12**: 115–75.

Huffaker, C. B. 1948. A technique for translocation of DDT in plants. JOUR. ECON. ENT. **41**: 650–1.

Reiber, H. G., and E. M. Stafford. 1946. DDT deposit and residues on olives, grapes, cabbage, green beans and peas. Calif. Agr. Expt. Sta. Circ. **355**: 104–8.

Schechter, M. S., S. B. Soloway, R. A. Hayes and H. L. Haller. 1945. Colorimetric determination of DDT. Color test for related compounds. Anal. Ed., Jour. Indust. and Engin. Chemistry **17**: 704–9.

Smith, R. F., O. H. Fullmer and P. S. Messenger. 1948. DDT residues on alfalfa hay and alfalfa seed chaff, JOUR. ECON. ENT. **41**: 755–8.

Smith, R. F., W. M. Hoskins, and O. H. Fullmer. 1948. Secretion of DDT in milk of dairy cows fed low-residue alfalfa hay. JOUR. ECON. ENT. **41**: 759–63.

The Toxicity of Certain Organic Insecticides to Honeybees[1]

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Losses of honeybees due to insecticidal poisoning have been, for many years, one of the most serious problems facing the beekeeper. The toxicity of arsenical poisons to the honeybee has been so great that when these insecticides were used almost exclusively in the control of cotton insects the economic production of honey was impossible throughout much of the state. Several new organic insecticides have been found effective for cotton insect control and are generally recommended. Planters are using these materials in preference to the arsenicals in order to control cotton insect pests. Since honeybees are important pollinators of legumes and legumes are also treated with organic insecticides in the control of injurious pests it becomes desirable to obtain information regarding the toxicity of these organic materials to the honeybee. Such information will be valuable to the beekeeper in managing his bees for the production of honey from cotton and legumes and for the pollination of legume crops.

Some work has been conducted on the

[1] Technical contribution No. 1229 Texas Agricultural Experiment Station.

toxicity of DDT, benzene hexacholride, and chlordan. McGregor & Vorhies (1947) reported that colonies of bees located near cotton fields were sometimes weakened following applications of DDT to cotton, yet the colonies were able to maintain themselves and even store a surplus of honey. Eckert (1945) and Wilson (1946) reported median lethal dosages of DDT used as a stomach poison ranging from 4.6 mmg. to over 200 mmg. per bee. Bennighof (1947) placed drops of DDT solution on the abdomen of bees and found that 625 mmg. per bee produced 50 per cent mortality after 3.25 hours. Woodrow (1948) gave 30 to 48 mmg. of DDT per bee as the MLD when applied as a dust. Way and Synge (1948) sprayed bees with 160 mg. of DDT per 100 cc. of water and obtained a 50 per cent kill. Benzene hexachloride spray, 1.4 mg. per 100 cc. of water, killed 50 per cent of the bees. MLD's of 9.1 and .08 mmg. were found when DDT and benzene hexachloride were fed as stomach poisons. Eide (1947) reported that chlordan was not toxic to bees but that benzene hexachloride was highly toxic. Eckert (1948) found chlordan to be highly toxic as a contact poison, stomach poison, and fumigant.

The work herein reported was conducted during 1948 and 1949 at College Station, Texas, for the purpose of determining the toxicity of several organic insecticides when used as contact poisons against honeybees.

METHODS.—Italian bees of naturally mated stock were used in these experiments. Screenwire cylinders 3.5 inches in diameter and 7 inches long served as containers for the bees while they were being dusted. The dusting apparatus and cages into which the bees were released after poisoning were similar to those described by Gaines & Dean (1949). Fifty bees collected from the brood nest of a colony were placed in each screen cylinder cage and four of these cages were dusted simultaneously with a pre-determined dose of insecticide at 40 pounds pressure. The dust was allowed to settle for 30 seconds. after which the bees were immediately transferred to other cages for observation. The bottom sections of 3-inch ointment cans containing a one-third sugar-two-thirds water solution were placed in the cages as a food supply. Excelsior in the cans allowed the bees easy access to the food without danger of drowning.

Each series included four replicate cages of each dose and an equal number of checks or untreated bees. A minimum of 5 different doses which included a total of 20 cages or 1000 individuals were used to establish each dosage-mortality curve. Abbott's formula was used to calculate the percentage mortalities. Dosages were calculated on a pound per acre basis and changed to logarithms, and the per cent mortalities were changed to probits for calculating the dosage-mortality curves. The curves were calculated according to Bliss' (1938) method.

RESULTS.—The text following gives the median lethal dosages and figure 1 shows the dosage-mortality curves for the following four materials: (1) 5 per cent DDT-82 per cent sulphur—(2) 3 per cent gamma benzene hexachloride-40 per cent sulphur, (3) 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulphur and (4) 10 per cent chlordan-40 per cent sulphur. It will be noted that those dusts containing 3 per cent gamma benzene hexachloride are highly toxic. The application of this material, especially in high dosages caused an almost immediate loss of muscular control. In warm weather the bees ran and tumbled about, falling on their backs and otherwise exhibiting poor coordination. In cooler weather they were more prone to cluster quietly in one corner of the cage, but even then a few bees were usually trying to move about. On the first day there were usually almost as many moribund as dead bees, but most of the deaths occurred on the first and second days. The median lethal dosages for 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulphur and 3 per cent gamma benzene hexachloride-40 per cent sulphur were 1.9 and

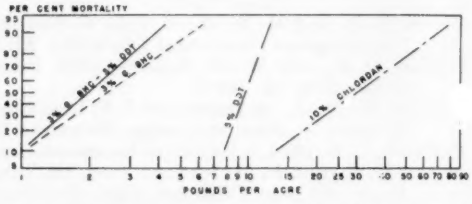

FIG. 1.—Dosage-mortality curves for the toxicity of insecticides as indicated when tested as contact poisons against the honeybee.

2.3 pounds per acre respectively. The DDT in the mixture had increasing effect at higher dosages.

The MLD for 5 per cent DDT-82 per cent sulphur was 9.6 pounds per acre. The reactions of the bees to DDT were not so immediate as to benzene hexachloride, and their actions after being dusted were more normal, but a loss of muscular control became obvious after a time. Most of the mortality occurred on the first day.

Temperatures seem to have more effect on chlordan than on any of the other materials tested. A test started on September 25 with 12 pounds of 10 per cent chlordan-40 per cent sulphur per acre, during which the average maximum and minimum temperatures ranged from 66° to 86° F., gave a 93 per cent mortality. This concentration was again applied on October 23, with the average daily temperature ranging from 69° to 76° F. and the resultant mortality was 30 per cent. Since it was considered possible that physiological changes in the bees concomitant to the cessation of brood rearing and the absence of a honeyflow, and not those directly caused by low temperature, may have been responsible for this decreased toxicity of chlordan, another series was begun on April 7 when brood rearing was at its height and there was a small honeyflow. The temperature range was approximately the same as that in the test of October 14, and the results were about equal. This indicates that lower temperatures decrease the mortality due to chlordan. The dosage-mortality curve for chlordan was drawn only from the data obtained after October 15 when the average maximum temperature was not over 76° F. On these tests the MLD was 29.95 pounds per acre.

Toxaphene was the least toxic of the materials tested. Twenty per cent toxaphene-40 per cent sulphur applied at the rate of 36 pounds per acre gave only 5 per cent mortality. A slight increase in the nervousness of the dusted bees over the checks was the only other effect noted.

SUMMARY.—Tests were conducted to determine the toxicity to the honeybee of several organic insecticides when used as contact poisons. It was found that insecticidal dusts containing benzene hexachloride were highly toxic. The median lethal dosages for 3 per cent gamma benzene hexachloride-40 per cent sulphur and of 3 per cent gamma benzene hexachloride-5 per cent DDT-40 per cent sulphur were 2.3 and 1.9 pounds per acre respectively. Five per cent DDT-82 per cent sulphur gave a MLD of 9.6 pounds per acre. The toxicity of 10 per cent chlordan-40 per cent sulphur varied greatly with the temperature. At temperatures below 76° F. chlordan was only slightly toxic, the MLD being 29.95 pounds per acre, but at 86° F. its toxicity increased greatly. Toxaphene was practically nontoxic, 20 per cent toxaphene-40 per cent sulphur giving only a 5 per cent mortality at 36 pounds per acre.

LITERATURE CITED

Bennighof, David C. 1947. DDT as a contact insecticide on honeybees and cockroaches. Bios 18(3): 189–95.

Eckert, J. E. 1945. The effect of DDT on honeybees. JOUR. ECON. ENT. 38(3): 369–74.

Eckert, J. E. 1948. Toxicity of some of the newer chemicals to the honeybee. JOUR. ECON. ENT. 41(3): 487–91.

Eide, Paul M. 1947. Experiments with insecticides on honeybees. JOUR. ECON. ENT. 40(1): 49–54.

Gaines, J. C., and H. A. Dean. 1949. Effect of temperature and humidity on the toxicity of certain insecticides. JOUR. ECON. ENT. 42(3): 429–33.

McGregor, S. E., and C. T. Vorhies. 1947. Beekeeping near cotton fields dusted with DDT. Ariz. Agr. Expt. Sta. Bul. 207.

Way, M. J., and A. D. Synge. 1948. The effects of DDT and benzene hexachloride on bees. Ann. Appl. Biol. 35(1): 94–109.

Wilson, Marie. 1946. DDT as a stomach poison for honeybees. Bios 17(3): 157–70.

Woodrow, A. W. 1948. Tests with DDT on honey bees in small cages. U.S.D.A., B.E.P.Q. E-763.

Control of the Imported Fire Ant in Alabama

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The imported fire ant, *Solenopsis saevissima* var. *richteri* Forel, has been a minor pest in the Gulf Coast area of Alabama for over 20 years. It was first officially reported in the United States at Mobile, Alabama, in 1930 (Creighton, 1930). The first official record known to the authors of damage being done by the ant was to young corn plants at the Alabama Agricultural Experiment Station's Gulf Coast Substation near Fairhope in the spring of 1935 (Smith & Yates, 1935).

In recent years the imported fire ant has spread to other areas and now occurs in at least 10 counties in southwestern Alabama as well as in Mississippi and Florida (Bruce *et al.* 1949; Wilson & Eads 1949). With increased numbers the ant has become a more important economic pest. It frequently attacks germinating seed and young, tender plants, builds unsightly mounds that may damage machinery, and is a vicious stinger.

An organized program to control the imported fire ant was carried out in Baldwin County, Alabama, in February, 1937 (Ruffin 1937). A cooperative control project in which cyanogas dust was used was promulgated by the Extension Service of the Alabama Polytechnic Institute, Alabama Department of Agriculture and Industries, Commissioner's Court of Baldwin County, and the Works Progress Administration. The Department of Agriculture and Industries provided a field supervisor; the Extension Service provided technical information and assisted in mapping out areas to be treated; the Commissioner's Court provided the cyanogas dust; and the Works Progress Administration provided the labor. One to 3 ounces of the "A" grade dust (forty-eight per cent calcium cyanide) was applied per hill by digging into the mound with a shovel, applying the dust, and covering it over with soil. Approximately 2000 acres of vegetable cropland were treated in this manner. Spot checks over the area showed extermination of the ants in at least 80 per cent of the treated mounds.

Ten per cent DDT, 5 per cent gamma benzene hexachloride, 25 per cent toxaphene, and 5 per cent chlordane dusts were shown to be effective treatments in the laboratory and in mounds in the field by Lyle & Fortune (1948). No results have been reported for broadcast dust treatments or for sprays.

Experiments on the control of the imported fire ant were conducted during 1949 by the Alabama Station at the Gulf Coast Substation at Fairhope and at the State Prison Farm at Atmore. In preliminary mound and small plot area treatments good control was obtained from DDT, toxaphene, benzene hexachloride, aldrin (1,2,3,4,10,10-hexachloro-1:4,5:8 diendomethano-1,4,4a,5,8,8a-hexahydronaphthalene), dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonaphthalene), and chlordane. Chlordane and aldrin were used in more detailed experiments. Further tests with the other insecticides are planned for future work.

Hill Treatments.—*Procedure.*—In locations where area treatments were not feasible, experiments were performed in the control of imported fire ant by applying insecticides to individual hills. Chlordane and other materials were applied as dusts. Chlordane was also applied in the form of emulsion sprays. Treatments were replicated 10 times.

Several methods of introducing the insecticide into the ant colony were tried. In one, the mound was simply stirred with a rake and the insecticide was mixed with the soil in the mound. In the second procedure a hole was driven approximately 18 inches deep into the center of the mound and the insecticide was introduced by dusting, spraying or pouring it into the opening. In the third procedure, three equally spaced holes were driven into the mound near the periphery and approximately equal quantities of insecticide were introduced into each hole. Examinations were made 15 to 30 days after treatment to determine the effectiveness of the treatments. When mounds were not conspicuously active, excavations to a depth of 18 to 24 inches were made to determine if live ants were present in the colony.

Results.—Results of hill treatments for control of the imported fire ant are presented in table 1. The most effective

Table 1.—Effect of chlordane and other insecticides after application to individual hills for control of imported fire ant at Atmore, 1949.

INSECTICIDE	RATE PER HILL	APPLICATION	% ACTIVE HILLS	% CONTROL[1]
None	—	—	90.0	—
5% chlordane emulsion	8 fl. oz.	In hole in center of hill (18″ deep)	15.0	83.3
5% chlordane emulsion	8 fl. oz.	Stirred into mound	0.0	100.0
10% chlordane dust	1 to 1.5 oz.	In hole in center of hill (18″ deep)	30.0	66.6
10% chlordane dust	1 to 1.5 oz.	Stirred into mound	5.0	94.4
None	—	—	85.0	—
2.5% chlordane emulsion	8 fl. oz.	In 3 evenly-spaced holes in hill (18″ deep)	15.0	82.4
2.5% chlordane emulsion	8 fl. oz.	Stirred into mound	0.0	100.0
10% chlordane dust	2 oz.	In 3 evenly-spaced holes in hill (18″ deep)	10.0	88.2
10% chlordane dust	2 oz.	Stirred into mound	0.0	100.0
None	—	—	100.0	—
3% γ. benzene hexachloride—5% DDT dust	2 oz.	Stirred into mound	0.0	100.0
20% toxaphene dust	2 oz.	Stirred into mound	0.0	100.0
2.5% aldrin dust	2 oz.	Stirred into mound	0.0	100.0
1% dieldrin dust	2 oz.	Stirred into mound	9.4	90.6

[1] Abbott's (1925) formula.

method used consisted of opening the mound and mixing the insecticide with the soil in the mound. Chlordane sprays and dusts were highly effective when applied in this manner. One-half pint of 2.5 per cent emulsion spray or 2 ounces of 10 per cent chlordane dust gave 100 per cent control in all tests. Where the material was introduced into one or more holes driven into the mound the treatment was somewhat less effective. Application of insecticide by dusting, spraying, and pouring was equally effective. Dusts of 20 per cent toxaphene, 3 per cent γ benzene hexachloride, 5 per cent DDT, 2.5 per cent aldrin, and 1 per cent dieldrin were also effective when stirred into the mound of the imported fire ant.

AREA TREATMENTS.—In some areas there were as many as 50 mounds per acre. Broadcast instead of mound treatments appeared to be feasible in such cases. Three experiments were conducted on an area basis.

Procedure.—The first test involved a simple dusting experiment in which chlordane and aldrin dusts were applied by a tractor duster to a pasture area covered by a good growth of white Dutch clover. The plots varied in size from 1.25 to 5 acres in area. The number of active mounds was determined previous to dusting, and 2 weeks and 2 months after the dusting.

Only chlordane was used in the second experiment. This test included dusts and sprays at 2 and 4 pounds per acre. Ten per cent dust was used on the 4-pound-per acre plots and 5 per cent on the 2-pound plots. The sprays were all 2.5 per cent emulsions. The effect of disking the insecticide into the soil was also tested. The soil was reasonably free of grass and weeds. Disking was done with a tractor-drawn disk tiller. The dusts were applied with an eight-row tractor duster and the emulsions were applied with a mule-drawn four-row sprayer. The plots were 1.25 acres in size. The treatments were applied on May 18, one week after the area had been burned over. The number of active mounds was recorded previous to and 60 days after the application of the treatments.

In a third test, 10 per cent chlordane dust and 2.5 per cent emulsion spray were applied in area treatments at the rate of 4 pounds of technical chlordane per acre. The dusts were applied broadcast with rotary type hand-dusters. The spray was applied with a power orchard sprayer. The correct amounts of insecticides were measured in advance and each area was covered lightly several times until all of the material had been used. One area was disked with tractor-drawn equipment following the application of 10 per cent chlordane dust. The area where this experiment was performed was rather low and damp. It was free of rank vegetation

Table 2.—Effect of chlordane and aldrin dusts on the imported fire ant at Fairhope, 1949.

Treatment	Number Active Mounds per Acre			Per Cent Control[2]
	Before Treatment	Two Weeks Later	Two Months Later	
None	54	61	63	—
2 lb. chlordane per acre	50	43	23	61
4 lb. chlordane per acre	44	38	6	88
1 lb. aldrin per acre	35	30	22	46

[2] Abbott's (1925) formula.

at the beginning of the experiment but later supported an abundant growth of grass and weeds which became quite dense. Where no disking was done, apparently the environment was not very suitable for the establishment of new ant colonies during the late spring and summer.

Results and Discussion.—Chlordane, at both 2 and 4 pounds per acre, when applied as dusts without disking the soil gave only fair control of the imported fire ant (Tables 2, 3, and 4), even where the soil was reasonably free of grass and weeds. Aldrin at one pound per acre as a dust was still less effective. However, when the soil was disked before the dusts were applied, both the 2- and 4-pound rates of chlordane gave well above 90 per cent eradication of the ants. Four pounds of chlordane as a dust applied previous to disking gave the same results in one experiment (Table 3); it gave 100 per cent control in another (Table 4). The results indicate that disking the soil is essential to good control when chlordane is applied as a dust. Whether the dust is applied previous or subsequent to disking appears to be of less importance than thoroughness of disking.

Chlordane emulsion sprays at the rates of 2 and 4 pounds of chlordane per acre,

Table 3.—Effect of various broadcast chlordane and cultural treatments on the imported fire ant at Fairhope, 1949.

Treatment	Number Mounds			Per Cent Control[3]
	Originally Active	60 Days After Treatment Active	Total	
None	23	40	56	—
No chlordane disked	29	22	27	56.4
4 lb. chlordane as dust, not disked	31	16	31	70.3
4 lb. chlordane as dust, applied before disking	67	6	12	94.8
4 lb. chlordane as dust, applied after disking	43	3	5	96.0
4 lb. chlordane as spray, applied after disking	42	6	21	91.8
2 lb. chlordane as dust, applied after disking	20	2	2	94.2
2 lb. chlordane as dust, not disked	17	8	17	72.9
2 lb. chlordane as spray, applied after disking	32	4	5	92.8
2 lb. chlordane as spray, not disked	39	7	14	89.7

[3] Abbott's (1925) formula.

Table 4.—Results of area treatments with 4 pounds technical chlordane per acre for fire ant control at Atmore, 1949.

Treatment	Active Hills per Acre			Per Cent Control[4]
	Before Treatment	15 Days After Treatment	107 Days After Treatment	
No insecticide; not disked	81.6	69.6	36.0	—
No insecticide; disked	79.6	—	36.0	2.3
10% chlordane dust; not disked	70.2	18.2	9.1	70.5
10% chlordane dust followed by disking	90.1	—	0.0	100.0
2.5% chlordane emulsion spray; not disked	76.5	10.5	3.0	91.2

[4] Abbott's (1925) formula.

applied after the soil was disked, gave above 90 per cent control of the ants in all experiments. However, 2 pounds of chlordane applied as a spray without disking gave 89.7 per cent control over a 60-day period (Table 3). In another experiment 4 pounds gave 91.2 per cent control over a period of 107 days (Table 4). Disking appeared less essential for control with sprays than with dusts.

A marked reduction in the number of active mounds was noticeable within two weeks following application of chlordane. However, the ants continued to die for at least 60 days following treatment. In one area, 100 per cent control was still being effected 107 days after disking in 4 pounds of chlordane as a dust.

In one experiment disking alone eliminated about 50 per cent of the active mounds for a 60-day period. In another there was no reduction below the number on untreated checks. It is doubtful if one disking substantially reduces the ant population. The rate at which the mounds are rebuilt may vary with the season of the year. In cool weather the ants are somewhat inactive. A greater increase in the number of active mounds on untreated areas was recorded from May to July than from March to May.

SUMMARY.—Experiments were conducted on the control of the imported fire ant, *Solenopsis saevissima* var. *richteri* Forel, at two locations in Alabama.

The most effective treatment of individual hills was opening the mound and mixing insecticide with the soil in the mound. One-half pint of 2.5 per cent chlordane emulsion spray or 2 ounces of 10 per cent dust was highly effective when applied in this manner. Two ounces of dusts of 20 per cent toxaphene, 3 per cent gamma benzene hexachloride–5 per cent DDT, 2.5 per cent aldrin, and 1 per cent dieldrin were also effective.

Above 90 per cent control of fire ants was obtained on area treatments when 2 or 4 pounds of chlordane as dusts or emulsion sprays was disked into the soil. Considerably less control resulted from dusts when the soil was not disked. Whether the dust was applied previous or subsequent to disking appeared to be of less importance than thoroughness of disking. Emulsion sprays were almost as effective without disking as when disking was done.

LITERATURE CITED

Abbott, W. S. 1925. Method of Computing the Effectiveness of an Insecticide. JOUR. ECON. ENT **18**: 265–7.

Bruce, W. G., J. M. Coarsey, Jr., M. R. Sith, and G. H. Culpepper. 1949. Survey of the Imported Fire Ant, **Solenopsis saevissima** var. **richteri** Forel. U.S.D.A. Bur. Ent. and P.Q. Special Report S-15.

Creighton, W. S. 1930. The New World Species of the Genus Solenopsis. Proc. Amer. Acad. Arts and Sci. **66**: 88, 89.

Lyle, Clay and Irma Fortune. 1949. Notes on an Imported Fire Ant. JOUR. ECON. ENT. **41**: 833–4.

Ruffin, W. A. 1937. Unpublished Annual Report of Extension Entomologist of the Alabama Polytechnic Institute.

Smith, M. R., and Harold Yates. 1935. Unpublished Letter from Smith to Yates, Acting Superintendent, Gulf Coast Substation of the Ala. Agr. Expt. Sta.

Wilson, E. O. and J. H. Eads. 1949. A Report on the Imported Fire Ant, *Solenopsis saevissima* var. *richteri* Forel, in Alabama. Special Report to the Alabama Department of Conservation.

NORTH-CENTRAL STATES BRANCH TO MEET IN KANSAS CITY

The annual meeting of the North-Central States Branch of the Association will be held in Kansas City, Missouri, March 23 and 24, with headquarters at the Hotel President. Dr. Geo. M. List is Chairman of the branch and Dr. J. W. Apple is Secretary.

Absorption of Benzene Hexachloride in Poultry[1,2]

D. P. Furman and R. A. Bankowski

The scarcity of certain insecticides during and immediately subsequent to World War II created a demand for a substitute material effective in controlling poultry ectoparasites when used as a roost paint. Benzene hexachloride was shown to have the required effectiveness, at least against several of the commoner species of poultry lice, as was reported by several workers (Roberts & Peterson, 1947; Creighton, *et al.*, 1947; Telford, 1947; Edgar *et al.*, 1949). Its effectiveness as a poultry roost paint against the chicken body louse, *Eomenacanthus stramineus*, was also demonstrated in small scale experiments by the present authors in 1947[3]. Peterson in 1949 reported that benzene hexachloride applied to roosts as a spray suspension of 0.25 per cent gamma isomer content controlled *Dermanyssus gallinae* for at least several months.

As early as 1946 Guilhon reported that a crude mixture of isomers of benzene hexachloride had a relatively low toxicity for chickens, the lethal dose for a chicken being given as 5 grams per kg. of body weight as compared to 2.5 gm./kg. body weight for a rabbit.

In 1947 Hixson & Muma indicated that benzene hexachloride was objectionable for use about the poultry house. They found off odors and flavor in the flesh of birds 2 weeks following treatment in which birds or houses were sprayed with aqueous suspensions of benzene hexachloride or when the chemical was administered in the feed.

Telford (1947), however, found that no tainting of eggs or of chickens occurred when benzene hexachloride was applied to roosts at a concentration of 1.27 per cent gamma content in fuel oil. Good but not always complete control of poultry lice was obtained with a single application.

Subsequent reports by Milby & Lawatsch (1948) and Edgar *et al.* (1949) indicated no off flavors or odors resulted in the flesh or eggs of birds following various applications of benzene hexachloride as solutions in oil for roost paints, as dusts applied to litter, and even, in the former report as an oil solution of 1.5 per cent gamma content sprayed on the birds.

The present work was designed to determine the presence or absence of benzene hexachloride absorption from variously treated roosts using a more sensitive and reliable method of analysis than the taste test.

Thirty-six chickens approximately 6 weeks of age were divided among five units of a poultry house, each unit being provided with an unpainted roost approximately 3 feet long. Roost treatments were applied by painting the test formulations in quantities just adequate to drench the roost top without causing appreciable run-off. The formulations were applied as follows:

1. Solution containing 0.5 per cent of gamma isomer of benzene hexachloride in a mixture of light fuel oil and kerosene.
2. Aqueous suspension containing 0.5 per cent of gamma isomer plus the other isomers present in technical benzene hexachloride.[4]
3. Aqueous suspension containing 1.2 per cent gamma isomer plus other isomers present in technical benzene hexachloride.[4]
4. Aqueous suspension containing 2.4 per cent gamma isomer plus other isomers present in technical benzene hexachloride.[4]
5. Aqueous suspension containing 2.4 per cent gamma isomer without other isomers of benzene hexachloride.

At the intervals shown in table 1 following treatment of the roosts, birds from each unit were sacrificed and the indicated tissues analyzed by bioassay for the presence of toxicity to houseflies due to absorption of benzene hexachloride and represented by gamma isomer equivalents. Tissue extracts from 2 birds of the group not exposed to treated roosts were found nontoxic to houseflies.

The bioassay method used in these investigations was a modification of that given by Furman & Hoskins (1948) which has been described in detail by Hoskins & Messenger. It consists essentially in chloroform extraction of tissues, removal of interfering extractives with sulphuric acid, followed by a standardized exposure of houseflies to the evaporated extract.

[1] A contribution from the Division of Entomology and Parasitology and the School of Veterinary Medicine, University of California, Berkeley.

[2] The cooperation of Dr. R. J. Bouthilet in conducting taste and odor tests and of Mr. P. S. Messenger in carrying out the bioassays is gratefully acknowledged.

[3] Unpublished data.

[4] Technical benzene hexachloride of 12 per cent gamma isomer content.

Table 1.—Amounts of benzene hexachloride, expressed as γ isomer equivalents, in tissues from poultry exposed to treated roosts.

TYPE OF ROOST TREATMENT	DAYS EXPOSURE TO ROOST	PPM γ ISOMER EQUIVALENT		
		Skin	Flesh	Liver
Solution of 0.5% gamma isomer (Lindane) in mixture of light oil and kerosene	2	0.41	0	0
	14	0	0	0
Suspension of 0.5% gamma isomer plus isomers present in technical benzene hexachloride	2	0	0	0
	14	0	0	0
Suspension of 1.2% gamma isomer plus other isomers present in technical benzene hexachloride	2	>3.26	0.45	0.74
	14	0.48	0.07	0.43
	21	3.20	0.17	0.43
	42	0	0	0
Suspension of 2.4% gamma isomer plus other isomers present in technical benzene hexachloride	2	8.65	2.40	0.74
	14	2.91	0.32	0.41
	21	2.54	0.31	0.31
	42	0	0	0
Suspension of 2.4% gamma isomer	2	>0.37	>0.20	>0.44
	14	4.00	0.26	0.31
	21	4.12	0.25	0.32
	42	0.61	0	0

Approximately 40 flies were used per test. Standard dosage-mortality lines for gamma benzene hexachloride were plotted according to the probit-log dosage procedure of Bliss (1934).

Concurrently with the absorption-bioassay tests for the presence of benzene hexachloride in poultry tissues, taste and odor tests were conducted with another series of chickens. Roosts were treated in the same manner with the suspension described above as formula No. 4, containing 2.4 per cent gamma isomer. These tests were conducted by Dr. Bouthilet of the University of California, Poultry Husbandry Division. Birds were sacrificed daily for over 2 weeks following treatment of roosts. Following cleaning, they were quick frozen and later tested for off flavors or odors by a standard taste panel method.

RESULTS.—From the data given in table 1, it is seen that benzene hexachloride as measured by gamma isomer equivalents was not recovered from the flesh, or liver of birds exposed to roosts painted with either the solution of Lindane or the suspension of benzene hexachloride containing 0.5 per cent of gamma isomer. However, a slight contamination of the skin was indicated in the former case two days post treatment. When roosts were painted with suspensions of mixed isomers benzene hexachloride containing 1.2 to 2.4 per cent of gamma isomer or with a suspension containing 2.4 per cent Lindane alone, absorption of the material did occur in each of the tissues examined. The greatest quantity, 8.65 parts per million, was obtained from the skin of a bird following 2 days exposure to a treated roost. In all but one case the tissues of continuously exposed birds became negative for the gamma isomer of benzene hexachloride between 3 to 6 weeks following treatment of the roosts.

As indicated in table 1 the upper limits of the amount of benzene hexachloride present in certain tissue tests were not determined due to the fact that the amount of tissue extracted with respect to the quantity of gamma isomer equivalents present was too great to register as anything but complete mortality of the test flies. In subsequent tests the size of the samples was reduced to whithin the range of sensitivity of the bioassay method.

For practical purposes the results of the taste panel method for detection of benzene hexachloride in birds exposed to treated roosts were negative. In attempts to standardize a taste panel to check on the possible tainting of flesh, uniformly negative results were obtained from all members of the panel even when birds were examined following 2 to 5 days ex-

posure to treated roosts. It should be noted here that a slight odor of benzene hexachloride was apparent to one *ex-officio* member of the panel who was quite familiar with the characteristic odor of the compound.

DISCUSSION.—From the results obtained in these experiments it is obvious that benzene hexachloride is absorbed by poultry tissues following use of the insecticide as a roost paint at the usual concentrations used to control poultry lice, *i.e.*, over 1 per cent of gamma isomer. This absorption takes place following applications of either high gamma preparations or technical benzene hexachloride containing a mixture of isomers.

In spite of the fact that absorption of benzene hexachloride was demonstrated to occur in poultry tissues following the described roost treatment, the amount absorbed was too slight to be detected by the average individual as a tainting or off odor of the tissues even at the highest concentration used. This concentration, a mixture of isomers containing 2.4 per cent of gamma isomer, is higher than necessary to control poultry lice, and if a pure gamma material were to be used the possibility of tainting would be further minimized.

For practical purposes it appears that the gamma isomer of benzene hexachloride disappears from the tissues of poultry in from 3 to 6 weeks following treatment of roosts in the manner described herein.

SUMMARY.—As demonstrated by a microbioassay technique, benzene hexachloride was absorbed by poultry tissues following treatment of roosts with various formulations of the compound. The level of absorption was below the average threshold of detection by taste and odor tests. Absorption was demonstrated following the use of either high gamma preparations, or a mixture of the isomers of benzene hexachloride. Absorption was not demonstrable by bioassay following roost treatments of material containing 0.5 per cent gamma isomer except for a very slight amount present in the skin of one bird. When formulations containing 1.2 to 2.4 per cent gamma isomer were used, absorption was demonstrated in skin, flesh and liver.

Although chickens were continuously exposed to treated roosts, their tissues lost their toxicity, as measured by bioassay, within 3 to 6 weeks following roost treatment, except in one instance where a residual toxicity was detected in the skin.

LITERATURE CITED

Bliss, C. C. 1934. The method of probits. Science **79**: 409–10.

Creighton, J. T., A. Hetrick, P. J. Hunt, and D. U. Duncan. 1947. Application of chlorinated hydrocarbons to the soil and roosts effectively controls lice of poultry. Poultry Science **26**: 674–5.

Edgar, E. H., W. L. Walsh, and L. W. Johnson. 1949. Comparative efficacy of several insecticides and methods of application in the control of lice of chickens. Poultry Science **28**(3): 320–38.

Furman, D. P., and W. M. Hoskins. 1948. Benzene hexachloride in cream from cow's milk. JOUR. ECON. ENT. **41**(1): 106.

Guilhon, M. J. 1946. Recherches sur les proprietes insecticides et sur la toxicite de l'Hexachlorocyclohexane. Comptes Rendus de l'Acad. Agric. de France **32**(5): 158–60.

Hixson, E., and M. H. Muma. 1947. Effect of benzene hexachloride on the flavor of poultry meat. Science **106**:2757): 422–3.

Hoskins, W. M., and P. S. Messenger. 1949. A microbioassay method for residues of insecticides in plant and animal tissues. MS in press.

Milby, T. T., and M. F. Lewatsch. 1948. The effect of benzene hexachloride on the flavor of poultry meat and notes on its use for the control of external poultry parasites. Poultry Science **27**: 245–7.

Peteron, E. H. 1949. Field tests of some insecticides in the control of common red mite of poultry and of the northern fowl mite. Poultry Science **28**(3): 411–4.

Roberts, I. H., and H. O. Peterson. 1947. Hexachlorocyclohexane—a fumigant for the control of chicken lice. Poultry Science **26**(6): 588–93.

Telford, H. S. 1947. Benzene hexachloride to control certain insects affecting domestic animals. JOUR. ECON. ENT. **40**(6): 918–21.

SCIENTIFIC NOTES

Control of the Suckfly on Tomato

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Heavy infestations of the suckfly, *Dicyphus minimus Uhler*, usually result in a discoloration of foliage, blasting of the flowers, and the shortening of the life of infested tomato plants.

During the 1947 and 1948 growing seasons, this pest was present in small numbers in Lower Rio Grande Valley tomato fields without causing appreciable damage. However, during the spring and early summer of 1949, it was present in destructive numbers in practically all tomato fields where control measures were not applied.

Prior to the season of 1949, the last destructive infestation of record in the Lower Rio Grande Valley was reported by Clark in 1934. Jones (1933) and Clark (1934) obtained satisfactory commercial control with applications of finely ground sulphur. Further research was initiated in 1949 to determine the effectiveness of more recent organic insecticides in controlling the tomato suckfly.

Two experiments were conducted during the harvesting period in 1949. The tomatoes had been planted in rows spaced 3 feet apart and with the plants spaced 1 foot apart in the rows. The research plots were 0.02 acre in size. The treatments, shown in tables 1 and 2, were applied with rotary hand dusters at approximately 35 pounds per acre. Each treatment was replicated three times. The efficiency of the various insecticides as a control for the suckfly was determined by taking net sweeps at definite time intervals after the treatment applications.

Table 1.—The effectiveness of insecticidal dusts in controlling the suckfly.

Treatments	Average Number Suckflies in 10 Net Sweeps		
	Days after Dusting		
	1	4	7
5.0% DDT in talc	72.0	10.7	26.0
5.0% DDT+82% sulphur	1.7	4.3	8.3
1.0% Lindane in talc	0.1	16.0	8.3
5.0% Methoxychlor in talc	0.0	2.7	3.0
Sulphur	101.7	70.3	70.3
Untreated	143.7	176.7	186.3

The data in table 1 show that sulphur will only reduce the suckfly population 60 per cent, 7 days after treatment application. The data also indicate that sulphur as an insecticide is much slower in action than a combination of DDT and sulphur in reaching its maximum effectiveness. The data in table 1 show that the addition of sulphur increased the effectiveness of a 5.0 per cent DDT dust. As can be seen by the data, the following dusts; 1.0 per cent lindane, 5.0 per cent methoxychlor, and a mixture of 5.0 per cent DDT and 82 per cent sulphur were all effective in controlling the suckfly.

As shown by the data in table 2, dusts containing 5.0 per cent chlordane or 10.0 per cent toxaphene with 40 per cent sulphur were just as effective as the mixture 5.0 per cent DDT and 82 per cent sulphur. A 1 per cent parathion dust was also very effective, but the data indicate that parathion was losing its residual toxicity faster than the DDT-sulphur mixture. A dust containing 5.0 per cent dichlorodiphenyl dichloroethane proved to be of little value for control of the suckfly.

Table 2.—The effectiveness of insecticidal dusts in controlling the suckfly.

Treatments	Ave. No. Suckflies in 20 Net Sweeps		
	Days after Dusting		
	1	2	9
1.0% Parathion in talc	0.0	4.3	24.3
5.0% DDT+82% sulphur	13.0	0.7	3.3
10% Toxaphene+40% sulphur	0.0	2.0	3.7
5.0% Chlordane in talc	1.7	0.7	7.0
5.0% Dichlorodiphenyl dichloroethane[1] in talc	99.0	147.7	262.0
Untreated	173.3	431.7	601.7

[1] Commonly called DDD or Rhothane.

Literature Cited

Clark, S. W. 1934. Tomato suckfly. Tex. Agr. Expt. Sta. 47th Ann. Rept. p. 239.

Jones, S. E. 1933. Uses of sulphur as an insecticide. Texas Agr. Expt. Sta. 46th Ann. Rept. p. 49.

Interference of Sulphur with Bioassay Dip Test

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A very sensitive technique for bioassay of insecticides has been used in this laboratory for some time. Recently when tests were extended to commercial agricultural dusts it was noted that products containing DDT and sulfur gave lower mortality than products containing the same amount of DDT alone. An effort was made to determine the cause and nature of the interference.

TECHNIQUE.—From the product an acetone solution or extract is made which contains 50 to 100

Table 1.—Concentration to give 50 per cent mortality of houseflies.

Material	LD 50 Dilution, Micrograms per Ml.	
	Without Sulfur	With Sulfur
Lindane	1	1+
pp′ DDT	10	80
Dichlorodiphenyl dichloroethane	20	70
Methoxychlor	40	50

times the concentration of insecticide to be used in the test. This solution is diluted with distilled water to produce a very finely-divided suspension of the desired concentration. Adult houseflies of test age are confined in a shell vial with a cheesecloth cover. The vial is half-filled with the suspension and shaken vigorously 25 times (15 seconds) to wet each insect thoroughly and evenly. The excess suspension is flipped out and the wet flies are transferred to a clean recovery cage for 24 hours before the mortality count is made.

Houseflies can be shaken for as long as a minute in acetone-water solutions containing up to 10 per cent acetone without producing any significant mortality but it is advisable to keep the percentage of acetone at about one or two per cent.

RESULTS AND DISCUSSION.—A dosage of DDT sufficient to kill 100 per cent of the flies gave approximately 10 per cent mortality when sulfur was present in the acetone solution.

Flies shaken first in a sulfur suspension and then immediately in a DDT suspension showed no interference by the sulfur. Dips prepared from extracts made with aniline as a solvent instead of acetone failed to show any interference due to the presence of sulfur.

Aliquots of dips were dried in petri dishes and flies were exposed to the residues. No inhibiting effect was detectable, in fact there was slightly greater mortality in the dishes which contained sulfur.

Most of the above-mentioned tests were run with pp′ DDT but a series of tests with lindane, dichlorodiphenyl trichloroethane and methoxychlor showed the same effect to a somewhat lesser degree. The comparison is shown in table 1.

SUMMARY.—Sulfur in acetone solutions of certain organic insecticides inhibits the toxic action of the insecticides in a bioassay dip test. It does not decrease the toxicity of residual deposits.

Effect of Several Insecticides on Sheep Tick Pupae

ROBERT A. HOFFMAN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

In view of the long pupal period of the sheep tick, *Melophagus ovinus* (L.), reported by Swingle (1913) and others to be often in excess of 30 days, it appeared desirable to obtain an insecticide that would destroy adults and pupae simultaneously. Therefore, laboratory tests were made at Corvallis, Ore., in 1948 to evaluate several of the chlorinated hydrocarbon insecticides, parathion, and rotenone for this purpose.

Sheep tick puparia were collected from heavily infested animals and brought to the laboratory. The pupae were necessarily of all ages as it was not possible to segregate them according to age. Parallel series of tests, one series with and one without 5 per cent of a wetting agent,[1] were conducted in which puparia were dipped in 0.5 per cent suspensions of DDT, dichlorodiphenyl dichloroethane, benzene hexachloride, methoxychlor, toxaphene, and chlordan. The wetting agent was used in these tests because it was believed such an agent might permit or assist the penetration of the puparia. Parathion was used at 0.01 per cent and rotenone at 16 ounces to 100 gallons of water or .006 per cent. All the insecticides were commercially prepared wettable powders, and contained unknown amounts and kinds of wetting agents. The source of the rotenone was cube root containing 5 per cent of the active ingredient. After being dipped the puparia were placed on absorbent paper until the surplus fluid drained. They were then transferred to perti dishes and maintained between two layers of army-type wool cloth. Two tests were then made in which the pupae were held at room temperature (65°–80° F.), and one test was conducted at a constant temperature of 80° and a *relative humidity of 50 to 70* per cent.

The results are summarized in table 1. The low emergence of the untreated pupae at room temperature was probably due in part to the irregular and low temperatures maintained during the test period. None of the compounds, either with or without the wetting agent, showed any appreciable mortality of pupae, except possibly methoxychlor when used with the wetting agent in both tests and parathion in the tests at 80° F.

Table 1.—Per cent emergence of ticks from puparia dipped in suspensions of various chemicals and held at room temperature or at a constant temperature of 80° F.

CHEMICAL	AT ROOM TEMPERATURE (35 PUPARIA PER TEST)		AT CONSTANT TEMPERATURE OF 80° F. (20 PUPARIA PER TEST)	
	Without Wetting Agent	With Wetting Agent	Without Wetting Agent	With Wetting Agent
DDT	23	31	45	30
Dichlorodiphenyl dichloroethane	23	20	40	25
Benzene hexachloride (12.8 per cent gamma)	37	31	65	65
Methoxychlor	31	14	75	25
Toxaphene	29	23	35	50
Chlordane	26	26	30	55
Parathion	20	23	5	10
Rotenone	34	23	30	30
Check (Untreated)	31	31	45	45

It is concluded that the common insecticides used as sprays or dips for control of the sheep tick cause little, if any, mortality of pupae, and that the addition of a wetting agent does not enhance the effectiveness of the materials.

LITERATURE CITED

Swingle, L. D. 1913. The life history of the sheep tick, *Melophagus ovinus*. Wyo. Agr. Expt. Sta. Bul. 99.

[1] An aralkyl polyether alcohol. *Triton-X-100.*

Laboratory Tests with Various New Insecticides Against the Sheep Tick

C. M. GJULLIN, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

Tests to determine the effectiveness of 20 insecticides against the sheep tick, *Melophagus ovinus* (L.), were made at Corvallis, Oregon. Ticks collected from sheep were exposed on khaki wool patches that had been dipped in 0.8 cc. of acetone containing the insecticide. The area of each cloth patch was 2.4 square inches. The entire solution was absorbed by the cloth. After the acetone had evaporated, the cloth patches were placed in 100-cc. beakers and ticks were exposed to the insecticide for 30 minutes. Tests were made at a room temperature of about

Table 1.—Toxicity of high dosages of insecticides to the sheep tick as determined by 30-minute exposures on wool cloth treated with acetone solutions.

Insecticide	Number of Tests	Milligrams of Active Ingredient per Sq. Ft.	Per Cent Mortality in 24 Hours
DDT	4	500	42
	6	250	57
	5	25	10
1 dichloro-2,2-bis (p-chlorophenyl)ethane	1	250	100
	1	50	100
	4	25	5
Chlordane	1	250	100
	1	50	100
	5	25	36
Benzene hexachloride (12.8 per cent gamma)	1	250	100
	1	50	100
	4	25	50
Heptachlor	13	25	97
Toxaphene	1	250	100
	1	50	80
	4	25	15
Aldrin[1]	4	25	90
Methoxychlor	1	250	100
	1	50	80
	4	25	10
1,1,1-Trichloro-2,2-bis (p-fluorophenyl)ethane	1	50	80
	4	25	20
Test product No. 153[2]	4	25	70
Rotenone suspension in 10 per cent water and 90 per cent acetone	5	25	12
Rotenone dissolved in benzene	3	25	0
1 part pyrethrins to 9 parts piperonyl butoxide	5	2.5	56
1 part pyrethrins to 9 parts piperonyl cyclonene	4	2.5	80
Pyrethrins	5	25	56
Gamma benzene hexachloride	5	25	100
Parathion	1	5	100
Dieldrin[3]	2	25	100
Test product as aliphatic thiocyanate[4]	4	25	15
Sodium arsenite	4	25	10
Nicotine sulphate (40 per cent nicotine	4	25	20
None	30		3
DDT	4	500	42
	6	250	57
	5	25	10
Dichlorodiphenyl dichloroethane	1	250	100
	1	50	100
	4	25	5
Chlordane	1	250	100
	1	50	100
	5	25	36
Benzene hexachloride (12.8 per cent gamma)	1	250	100
	1	50	100
	4	25	50
Heptachlor	13	25	97
Toxaphene	1	250	100
	1	50	80
	4	25	15
Aldrin[1]	4	25	90
Methoxychlor	1	250	100
	1	50	80
	4	25	10
1,1,1-Trichloro-2,2-bis(p-fluorophenyl)ethane	1	50	80
	4	25	20
Test product No. 153[2]	4	25	70
Rotenone (in 90 per cent acetone)	5	25	12
Rotenone (in benzene)	3	25	0
Pyrethrins (100 per cent)-piperonyl butoxide (1:9)	5	2.5	56
Pyrethrins (100 per cent)-piperonyl cyclonene (1:9)	4	2.5	80
Pyrethrins	5	25	56
Gamma benzene hexachloride	5	25	100
Parathion	1	5	100
Dieldrin[3]	2	25	100
Test product Aliphatic thiocyanate	4	25	15
Sodium arsenite	4	25	10
Nicotine sulphate (40%)	4	25	20
None	30		3

Table 2.—Toxicity of low dosages of insecticides to the sheep tick as determined by 30-minute exposures on wool cloth treated with acetone solutions.

Insecticide	Number of Tests	Milligrams of Active Ingredient per Square Foot	Per Cent Mortality in 24 Hours
Parathion	2	1.5	100
	6	1	32
	4[1]	1	100
Heptachlor	7	.5	79
	4	2.5	70
Dieldrin	5	.5	64
	4	2.5	82
	2	1.5	70
Gamma benzene hexachloride	4	.5	75
	4	2.5	32
Aldrin[2]	5	.5	76
Checks	15	0	3

[1] Ticks exposed for 135 minutes.
[2] See notes, Table 1.

70° F. Fumigating effects from the insecticides used were reduced by placing the test beakers in the air current from a small fan. After the exposure period the ticks were transferred to beakers containing bits of cheesecloth and kept at temperatures ranging from 70° to 80° and an average humidity of about 75 per cent.

In the first series of tests (Table 1) 5 ticks per test were exposed for 30 minutes. Of the 20 insecticides evaluated 15 failed to give 100 per cent mortality in 24 hours on cloth treated at the rate of 25 mg. of insecticide per square foot. Among the insecticides that failed were DDT, dichlorodiphenyl dichloroethane, methoxychlor, chlordan, benzene hexachloride, toxaphene and rotenone (5 per cent cube powder). The alpha, beta, and delta isomers of benzene hexachloride, which are not shown in the table, were also ineffective.

The five insecticides causing 90 per cent or higher mortality in 24 hours were retested at lower dosages using 10 ticks per test (Table 2). Parathion, the most effective of this group, gave 100 per cent mortality at the 1.5-mg. dosage as compared with 82 per cent for some new experimental products[1] at 2.5 mg. per square foot. At 5 mg. per square foot the mortality for gamma benzene hexachloride was 75 per cent and for another experimental product,[2] 76 per cent. The average mortality on untreated checks was 3 per cent.

These tests indicate that several of the newer insecticides may be more effective than those now in use against the sheep tick. The results obtained by this laboratory method with DDT, rotenone, and benzene hexachloride are similar to those obtained with these materials in field tests, and the method appears to be an effective one for determining the initial toxicity as well as the residual effect of insecticides against the sheep tick.

[1] Julius Hyman 497 and 79 and "Heptachlor."
[2] Julius Hyman No. 118.

[1] 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4,5,8-dimethanonaphthalene. (Julius Hyman)
[2] Composition not disclosed. (Julius Hyman)
[3] 1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4,5,8-dimethanonaphthalene. (Julius Hyman)
[4] Lethane 70.

A New Cutworm on Cranberry

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There have been reported heretofore five different species of cutworms attacking cranberry bogs after late removal of the winter flood.[1] This paper reports a sixth species occurring on bogs under these conditions. It is known that still a few other cutworm species so occur very occasionally and very locally, but they have not yet been reared or identified.

Black cutworms and armyworms were found working on an area of the big Wankinco bog in

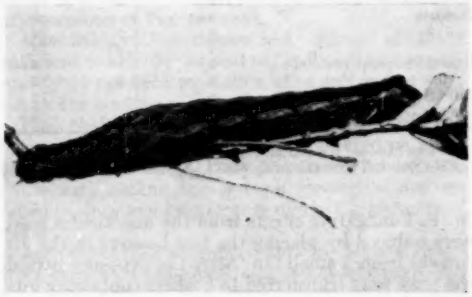

FIG. 1.—Caterpillar of *Hyppa xylinoides*. Enlarged.

Carver, Mass., on June 24, 1949, the winter flowage having been removed on May 23. Working with these two species were other cutworms, some of which were reared and were identified as *Hyppa xylinoides* (Gn.).[2] The description of these worms (Fig. 1) was as follows:

Length, full grown, fully an inch and a quarter. Body robust, prominent toward hind end of back. Color mostly rusty brown to black, with a rather

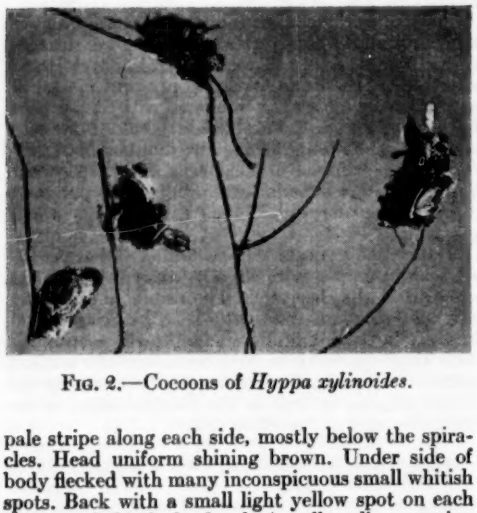

FIG. 2.—Cocoons of *Hyppa xylinoides*.

pale stripe along each side, mostly below the spiracles. Head uniform shining brown. Under side of body flecked with many inconspicuous small whitish spots. Back with a small light yellow spot on each side just behind the head. A yellow line running back from the head for a ways, down on each side. Most specimens rusty brown in their earlier stages and rather dimly variegated.

PUPATION.—The worms finally enclosed themselves in ample and substantial cocoons, on the surface of the bog sand or up among the vines somewhat, to pupate. The cocoons were made of various mixtures of balls of frass, cranberry leaves, and sand grains sewed together (Fig. 2), some of them being three-fourths of an inch long. The first cocoons were observed July 1. The pupae that formed in these cocoons were plain chestnut brown all over and fully five-eighths of an inch long.

MOTH.—The moths (Fig. 3) emerged from July 11 to 25, inclusive. Their description was as follows:

Length, head to tip of abdomen, about nine-sixteenths of an inch; spread fully an inch and a half. Color above medium gray; dorsum of thorax light gray, rimmed in front and on the sides with black; dorsum of abdomen light brown; under side of thorax clothed heavily with pale hair, that of ab-

FIG. 3.—Male moth of *Hyppa xylinoides*. Much enlarged.

domen covered with light reddish gray hair; fore wings mostly rather light gray above, variegated, with black and with white streaks toward and on the hind margin, the latter at the base and toward the outer end; under side of fore wings and upper side of hind wings pale toward the base, otherwise rather dusky brown, the former with four pale spots on the distal portion of the front margin and the fringes of the outer margin with whitish interruptions; under side of hind wings mostly pale but with a dark discal spot. Head gray, with a black cross-band between the upper ends of the eyes.

[1] Bul. 445, Mass. Agr. Expt. Sta., pp. 22–34.
[2] Identified by J. G. Franclemont. See Can. Ent., 2: 33, 1869.

A Biological Assay Method for Determining Aldrin[1, 2, 3]

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In general, the polychloro organic insect toxicants have not been amenable to simple methods of chemical analysis. Consequently, a biological assay method similar to that used by Laug (1946, 1948) has been developed for test material "118" which would appear to be of value, either in the case of laboratories not equipped to conduct the colorimetric procedure for the determination of aldrin, recently developed by Danish & Lidov (1949), or as a valuable supplementary method and check on the data obtained by chemical methods.

This method consists essentially of exposing uniformly sampled lots of adult house flies, *Musca domestica* L., to a residue of the new material for a period of 48 hours, and observing the resultant per cent mortality. A standard assay curve is established by plotting the per cent mortalities as probits against the milligrams of the insecticides per kilogram of houseflies (or micrograms per gram of flies). Residues containing unknown amounts of the material are concurrently assayed with uniformly sampled lots of flies from the same rearing. Values of the insecticide in the unknown residues are obtained from the standard curve for that day.

The adult houseflies used in these tests were reared according to the official NAIDM method for evaluating liquid household insecticides.[4]

The assay procedure consists of exposing approximately 100 flies (about 2 grams) to residues of the test material in wide-mouth quart mason jars. A standard solution of the insecticide in benzene was prepared so that 1 ml. of this solution contained 0.003 mg. of the actual chemical. A second solution of corn oil in benzene was prepared so that 1 ml. of this solution contained 20 mg. of the corn oil. In preparing the standard curve for each day's analyses, appropriate quantities of the standard solution were pipetted into the bottom of the clean, dry mason jars so that residual quantities of the insecticides were deposited, ranging from 0.001 to 0.005 mg. of the actual compound. In practically all cases, five levels of the test material (0.001, 0.002, 0.003, 0.004, and 0.005 mg. per jar) provided sufficient data for the construction of the standard curve. Earlier work, using only three levels of the compound (0.0015, 0.003 and 0.0045 mg. per jar) and plotting the per cent mortalities as probits against the logarithms of the milligrams of insecticide per kilogram of houseflies did not provide sufficient data to determine accurately the slope of the standard curve.

Following the addition of the standard solution to the jars, 1 ml. (20 mg.) of the corn oil solution was pipetted into each of the jars. The check jars contained only 1 ml. of the corn oil solution. In the case of the standards, the corn oil was added both to prevent possible loss of the test compound by evaporation and to approximate the fatty or waxy residues obtained from solvent (benzene and ether) extractions of animal and plant tissues. The bottom of each mason jar had an area of approximately 44 square centimeters. The extracts containing unknown amount of the insecticide were added in appropriate amount to additional mason jars. After some experience with the assay method, it was frequently possible to use suitable quantities of the unknown extracts without preliminary testing. The jars were shifted about while a gentle stream of air was used to evaporate the solvent. The possibilities of dispersing the residues over the sides and bottoms of the jars were explored, but this procedure failed to produce significantly greater deaths among the flies.

The adult flies were transferred, by means of a rapidly moving air stream, from the rearing cages to double, one-quart, cylindrical paper cartons, anesthetized with carbon dioxide according to the method reported by Williams (1946), thoroughly mixed, and approximately 2 gram aliquots shaken into 50×30 mm. glass-stoppered weighing bottles; with a little practice, the weight of the flies added to each weighing bottle can be estimated to within a few tenths of a gram. The still anesthetized flies were weighed quickly on a chain-weight analytical balance and transferred to a mason jar. A souffle cup[5] containing approximately 50 ml. of milk, (1 tall, 13 fluid ounce-can condensed milk diluted to 2 quarts with water), absorbed by a cellulose material to prevent drownings, was added to each mason jar which had been placed in a horizontal position. The diluted milk was identical with the solution used to feed the adult flies held in the rearing cages before being used in the assay procedure. A square of cheesecloth (approximately 30 mesh) was used to cover the jar, using the retaining ring provided with the jar to hold the cheesecloth securely in place. Each jar, containing both the flies and the milk, was left on its side and held for observation, preferably in a room provided with temperature control, such as a corner of the rearing room. If care is exercised in preventing over-anesthesia with the carbon dioxide, 100 per cent reversibility of the anesthetic effect is obtained.

A count of the dead flies was made at the end of 24 and 48 hours; flies that were moribund were included with the dead. Although the 24-hour count was not used in determining amounts of the toxicant, the mortality at this stage, particularly in the jars containing the unknown residues, frequently can provide guiding information for later analyses of the unknowns. From the amount of test material added to each of the standard jars and the total weight of the flies in each case, the milligrams of insecticide per kilogram of flies (or micrograms per gram of flies) is calculated for each level. Mortality data are converted to probits.

From the results of these standard assays, the average median lethal dose (LD_{50}) was 1.26 mg. of test material per kilogram of flies with a range of 1.10 to 1.66. The slopes of these same lines had an average value of 1.56 with a range of 1.29 to 1.75.

The sensitivity of the method allows for quantitative estimation of the toxicant down to 0.001 mg. (1 microgram). The mortality of the flies in the check jars never exceeded 3 per cent and was usually

[1] A new insect toxicant discovered and recently introduced by Julius Hyman & Company, Denver, Colorado, having an empirical formula of $C_{12}H_8Cl_6$ and the chemical name: 1,2,3,4,-10, 10- hexachloro-1, 4, 4a, 5, 8, 8a- hexahydro-1, 4, 5, 8-dimethanonaphthalene. See Literature cited Lidov *et al.* (1949).

[2] This publication is a report on one phase of cooperative investigation involving the Department of Veterinary Medicine and the Department of Entomology and supported by a research grant established at the Kansas Agricultural Experiment Station, September 1, 1948, by Julius Hyman & Company of Denver, Colorado. The coordinating committee consists of R. I. Throckmorton, E. E. Leasure, Roger C. Smith, C. H. Kitselman, A. R. Borgman and Paul A. Dahm. Statistical analyses and interpretations were made under the direction of H. C. Fryer, experiment station statistician.

[3] Contribution No. 568, Department of Entomology.

[4] Soap and Sanitary Chemicals Blue book for 1947.

[5] Lily-Tulip Souffle Cup No. 50 PB.

only 0 or 1 per cent at the end of 48 hours.

Unknown amounts of this compound in plant or animal extracts are calculated graphically by reference to the standard assay line which must be constructed for each set of determinations. This method has been used successfully to determine the presence or absence of the compound in such animal tissues or products as body fat, perirenal fat, liver, bile, muscle, blood, brain, kidney, spleen, feces and milk and on such forage crops as alfalfa. Comparable extracts of normal animal or plant tissue have been made and exposed to the flies as in the standardization method with no significant mortality resulting from these extracts.

LITERATURE CITED

Danish, A. A., and Rex E. Lidov. 1949. A colorimetric procedure for the determination of Compound 118. Paper presented at the 115th National Meeting of the American Chemical Society, San Francisco, California, Wednesday, March 30, 1949.

Laug, Edwin P. 1946. A biological assay method for determining DDT. J. Pharmacol. Expt. Therap. **86**(4): 324–331.

Laug, Edwin P. 1948. Tissue distribution of a toxicant following oral ingestion of the gamma isomer of benzene hexachloride by rats. J. Pharmacol. Expt. Therap. **93**(3): 277–281.

Lidov, Rex E., Henry Bluestone, S. Barney Soloway and Clyde Kearns. 1949. Alkali stable polychloro organic insect toxicants. Compound 118 and 497. Paper presented at the 115th National Meeting of the American Chemical Society, San Francisco, California, March 30, 1949.

Soap and Sanitary Chemicals Bluebook for 1947. Peet-Grady Method. 19th Ed.: 207–210.

Williams, C. M. 1946. Continuous anesthesia for insects. Science **103**(2663): 57.

A Field Method of Marking Arctic Mosquitoes with Radiophosphorus

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An exact method of marking individual mosquitoes and other biting flies has been desired for studies on the habits of disease bearing and pest mosquitoes in relation to control programs. In the American arctic, pest mosquitoes are extremely abundant during the short summers and it is of importance to know the flight range and dispersal of these insects. Previous methods of marking insects include the use of fluorescent and non-fluorescent dyes, gold and other metallic dusts. These methods necessitate killing or anesthetizing the insects, examination of each specimen, and may involve contamination of specimens.

Mosquitoes marked with radioactive tracers would permit widescale studies on dispersal, flight range, and migration. Large numbers of mosquitoes can be examined at one time without harming them. Laboratory reared *Aëdes aegypti* were made highly radioactive by Hassett & Jenkins (1949) by rearing third and fourth instar larvae, and pupae, in solutions of radioactive phosphorus as $NaH_2P^{32}O_4$, and by Bugher & Taylor (1949) by rearing in solutions of radioactive phosphorus P^{32} and strontium Sr^{89}.

Field studies were carried out on the eastern side of Hudson Bay at Great Whale River, Quebec, to determine the feasibility of using a radioactive tracer to mark wild arctic mosquitoes. Forty millicuries of radioactive phosphorus as $KH_2P^{32}O_4$ were received on 26 June 1949 from Chalk River, Ontario. By this date the more abundant species of arctic mosquitoes had mostly emerged so that it was impossible to treat large numbers of larvae for adult dispersal studies. The late occurring northern species *Aëdes pullatus* and *A. excrucians* were present in sufficient numbers to test the method and to run preliminary experiments.

Four pools were selected on a bare granite hill for the experiments. Fourth instar larvae and pupae were collected from nearby pools and were concentrated in the test pools. Radioactivity was measured by two Beta-gamma survey meters, a Beckman MX-5 and a Victoreen 263. The only radioactivity in and near the pools was a background of between 30 and 35 counts per minute equivalent to about 0.01 milliroentgens/hour. Wild mosquitoes examined before the tests showed no radioactivity. Two pools, A and B, were made radioactive while the other pools were controls.

POOL A. This small pool was 0.7 meters by 0.3 meters at the surface and 5 cm deep. It contained approximately 10.5 liters of clear, slightly acid water. About 200 larvae and 200 pupae of *Aëdes excrucians* were put into the pool on June 27. Three millicuries of P^{32} were mixed into the pool giving a concentration of 0.3 microcuries per ml. The radioactivity at the center of the pool measured 20 mr/hr[2] at 26 cm. above the surface. On June 28 a rain caused some of the water to overflow, and on June 29 the radiation from the pool was 20 mr/hr at 52 cm. because the surrounding rocks and a nearby pool below were slightly contaminated. On this date all larvae had transformed to pupae and a few adults had emerged. Washed dried pupae showed the following radiation at 1 cm: two pupae each gave 0.03 mr/hr or ca. 90 cts/min;[3] a third pupa which had been put into the pool as a larva gave 0.7 mr/hr or ca. 2,100 cts/min. Adult males showed an average activity of 1.5 mr/hr at 1 cm on July 1.

POOL B. This pool was 1.6 meters by 1.0 meter at the surface, about 8 cm in depth, and contained ca. 128 liters of slightly acid water. Approximately 8000 larvae and 10,000 pupae of *A. pullatus* and some *A. excrucians* were put into the pool on June 27. Twenty eight millicuries of P^{32} were mixed in the pool giving a concentration of about 0.2 microcuries per ml of water. The radiation measured above the pool was 20 mr/hr at 8 cm. On June 28 a rain increased the depth to about 13 cm. On June 29 the center of the pool measured 5 mr/hr at 8 cm above the surface, and the rock margins and shallow end measured 10 mr/hr at 8 cm. On July 6 the radiation of the pool was 2 mr/hr at 3 cm at the center, and 2 mr/hr at 6 cm at the margin of the pool. On July 6, fourth instar larvae, pupae, and emerged adult male and female *A. pullatus* and *A. excrucians* were collected and the radioactivities were measured with the results shown in Table 1. The larvae and pupae were washed and dried before measuring. About five specimens of each species were measured during each stage. All radioactivities were measured at 1 cm from the GM tube. Males and some females were collected

[1] Collaborator on the Northern Insect Survey of the Entomology Division, Department of Agriculture, Ottawa, Canada. Sponsored by the Canadian Defense Research Board.

[2] 1 mr/hr = milliroentgens per hour.

[3] cts/min = counts per minute.

as they emerged from the pools. Some radioactive females were collected in an insect net from the large swarms around the observer, and the radiation was measured while the insects were in the net.

The larvae from pool B showed a radiation of 18,000 to 25,000 cts/min, the pupae 10,500 to 12,000 cts/min, the adults 2100 to 5100 cts/min. The average adult mosquito radiation was 1.44 mr/hr or ca. 4300 cts/min. With this amount of radiation per adult, experiments could theoretically be carried on for 10 weeks or through 5 half lives of P^{32} at which time the adults would have a radioactivity of ca. 134 cts/min or about 4x background. This would be sufficient time for most dispersal and migration experiments, particularly since only females would be involved for such long periods of time. Egg laying and elimination would lower the amount of radiation so that higher initial radioactivities would be indicated for long experiments. For experiments involving longer periods of time other radio isotopes with longer lives can be considered.

Table 1.—Radioactivity from various stages of Aëdes mosquitoes produced under field conditions. (All figures in milliroentgens/hr.)

STAGE	*A. pullatus*	*A. excrucians*
Fourth instar larvae	6.0–6.5 ave. 6.3	7.0–8.5 ave. 7.5
Pupae	3.5–4.0 ave. 3.7	3.5–4.0 ave. 3.8
Males	0.7–1.4 ave. 1.13	1.4–1.6 ave. 1.5
Females	1.2–1.6 ave. 1.45	1.5–1.7 ave. 1.67

Radioactive females were collected about 30 meters away from the pools. Strong winds up to 37 m.p.h., and fog and rain, and snow prevented more extensive checking of dispersal around the pools. No unusual behavior or mortality was observed in the radioactive larvae, pupae, or adults. No radioactivity was observed from mosquitoes emerging from the control pools.

SUMMARY.—Fourth instar larvae and pupae of *Aëdes pullatus* and *A. excrucians* were treated with radioactive phosphorus as $KH_2P^{32}O_4$ at 0.2–0.3 microcuries/ml of water, under arctic field conditions at Great Whale River, Quebec.

Highly radioactive larvae, pupae, and adults were produced. The average radioactivity of the adults was 1.44 milliroentgens/hour or ca. 4300 cts./min.

This method for producing radioactively marked mosquitoes in nature can be recommended for dispersal, flight range, migration, predation, and other ecological studies.

LITERATURE CITED

Bugher, J. C., and M. Taylor. 1949. Radiophosphorus and radiostrontium in mosquitoes. Preliminary Report. Science **110**: 146–7.

Hassett, C. C., and D. W. Jenkins. 1949. Production of radioactive mosquitoes. Science **110**: 109–10.

Diachus auratus, a New Strawberry Pest in Utah

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During the latter part of July, 1948, and throughout the summer of 1949, a five-acre strawberry patch at Garden City, Utah, was observed to be heavily infested with a willow flea beetle, *Diachus auratus* F. Damage to the berries in 1948, was severe enough to cause more than 90 per cent of the fruit to be unfit for the market. According to the report of the owner, the bettles entered the field about the time the picking season commenced and left the field at the close of the picking season. In 1948, more than 60, and in 1949 more than 500 of the beetles were collected, all of which were females. Dissection of about 10 specimens collected during each visit to the infested field throughout the 1949 season, gave no indication of egg development.

When the field was visited June 21, 1949, the day before the berry picking season began, the beetles were found in abundance only at the upper end (west), near the center of the field where they were damaging all aerial parts of the strawberry plants, especially the fruit. They were observed to feed on the under surface and to a lesser extent on the upper surface of the leaves, the injury resembling typical skeletonizing of flea beetles. Damaged areas on the leaves soon turned dark in color similar to darkened areas on the stems; however the beetles were not observed to feed on the stems, and no freshly injured spots were noticed. About 10 per cent of the strawberry blossoms present were being fed upon by from one to four beetles which fed almost entirely at the base of the petals; injured blossoms died in from 2 to three days. The most serious damage was inflicted on the green strawberries which were one-third grown or larger; a few beetles were observed on partly ripened fruit, but none were observed on completely ripened berries.

About 50 per cent of the green strawberries were being attacked by from one to eight beetles which were found at the base of the berry under the calyx cap. From one to a complete ring of small depressions 0.06 to 0.12 inch in diameter and depth were eaten out under each calyx. Within 2 or 3 days after feeding at one depression stopped, the surrounding area turned brown and dried until the berry was dead.

Considerable sweeping of wild rose bushes, two species of willow, and other plants which border the west end of the field where the beetles were found, produced two specimens of the beetle from wild rose. No specimens were found in or on the ground, either in the strawberry patch, under rose bushes, or on willow trees. The bettles were not found on other strawberry fields, the nearest of which was 1.5 miles from the infested field.

The infested field was again visited July 6, at which time the beetles were more uniformly distributed throughout the patch and were not as abundant in any one spot as they had been on the previous visit; they were more active however, and dropped to the ground or took flight more readily than at the previous visit. More than 25 per cent of the berries had dried up, and half of those still alive were damaged. Nine additional specimens were collected from rose, and five were taken from willow at the upper end of the field.

July 14, the beetles were rather scarce on strawberries but quite abundant on rose blossoms on all sides of the field; they were less abundant on willow. Extensive sweeping on all sides of the field did not produce beetles at a greater distance than 30 feet from the strawberries. Beetles could not be found around the bases or in the soil around the strawberry plants, willow trees, or rose bushes. Three visits at about 10 day intervals since July 14, have shown a decrease in population until August 16, when beetles completely disappeared from strawberry plants, and only two specimens could be found, one on rose and one on willow.

Development of Resistance to Organic Insecticides Other Than DDT by Houseflies

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Following the failure of DDT residual sprays to achieve effective fly control in southern California due to the development of DDT-resistance by houseflies, effective control was obtained with other organic insecticides. Of the commercially available insecticides, the most effective was benzene hexachloride used at the rate of 17–20 pounds of the 10 to 12 per cent *gamma*-isomer wettable powder or 8 pounds of the 25 per cent *gamma*-isomer wettable powder per 100 gallons of finished spray. During the past fly season equally effective control was obtained with 4 to 8 pounds of dieldrin in form of a wettable powder[1] per 100 gallons. This material, available as yet only on an experimental basis, has shown considerable promise for fly control in extensive field experiments because of its high degree of toxicity and long residual activity.

On August 10, 1949, however, information was received from Mr. E. A. Dudley, Deputy Agricultural Commissioner for Orange County, that benzene hexachloride was not accomplishing satisfactory housefly control at a poultry ranch at Santa Ana, California.

The history of insecticidal treatment made at this ranch under the supervision of Mr. Dudley during 1949 for fly control is as follows: On March 28–29, 300 gallons of 2.5 per cent DDT (40 pounds of the 50 per cent DDT wettable powder per 100 gallons) were applied with unsatisfactory residual control. This result was very probable in view of the widespread occurrence of DDT-resistant houseflies in southern California. On April 11–12, 300 gallons of 0.25 per cent *gamma*-isomer of benzene hexachloride (17 pounds of the 12 per cent *gamma*-isomer wettable powder per 100 gallons) were applied with satisfactory residual control being obtained for a period of about 4 weeks. On May 16–18, 600 gallons of the same finished spray as used in April were applied, but satisfactory residual control lasted only about 3 weeks. On July 18–20, 850 gallons of the same finished spray were applied to the entire ranch. After 24 hours it was evident that control of flies was not as satisfactory as in previous applications, and after 5 days the fly population had returned approximately to the pre-spraying level. On August 12, 150 gallons of 0.75 per cent *gamma*-isomer of benzene hexachloride (50 pounds of the 12 per cent *gamma*-isomer wettable powder per 100 gallons) were applied to the south portion of the ranch. By August 15 there was a medium infestation of flies in the treated area. On August 16–17, 300 gallons of 0.25 per cent of the experimental compound (8 pounds of the 25 per cent 497 wettable powder per 100 gallons) were applied. By August 19, however, there was a heavy infestation of flies in the treated area.

Table 1.—Measured drop tests showing comparative 24-hour LD_{50}'s in micrograms per fly.

Compounds	24-Hour LD_{50}'s in Micrograms per Fly for Following Fly Strains		
	Pollard	Bellflower	Laboratory
DDT	10	11	0.033
Gamma-BHC	0.22	0.08	0.010
Dieldrin	1.4	0.05	0.031
Parathion	0.014	0.020	0.015

A sample population of houseflies was collected at the Pollard Ranch on August 19 and the relative degrees of resistance of the laboratory-reared progeny to various insecticides were determined in the same manner as had been previously accomplished by the authors for DDT-resistant houseflies (March & Metcalf 1949). These laboratory tests showed (Table 1) that the Pollard strain was as resistant to DDT as the most DDT-resistant field strain (Bellflower strain) previously collected. It showed, as well, an increase in resistance of 3 times to the *gamma*-isomer of benzene hexachloride and 28 times to the experimental compound when compared with the Bellflower strain. When compared with a laboratory strain of houseflies which had been continuously reared in the laboratory without ever having been exposed to insecticides, it showed a resistance of 300 times to DDT, 22 times to the *gamma*-isomer of benzene hexachloride, and 45 times to the experimental compound. All 3 strains showed approximately the same level of resistance to parathion.

It is apparent that the degrees of resistance shown by the Pollard strain to DDT, *gamma*-isomer of benzene hexachloride and the experimental compound are sufficient to make it impractical to use these materials for residual housefly control where such strains are present. The development of resistance by a single strain of houseflies to a number of chemically unrelated insecticides poses a serious problem for the entire field of insect control, and more currently housefly control, by the residual application of insecticides. It presages the further development of resistance to other insecticides which may be substituted for those against which resistance has developed. At present we have found no indication that resistant strains will revert to more susceptible strains following non-exposure to the insecticide. The Bellflower (DDT-resistant) strain has now been reared in the laboratory for over 28 generations without exposure to DDT and there has been no appreciable change in the DDT-resistance of the progeny.

These new developments, though as yet only on a limited scale, indicate that eventually standard fly control procedures may have to be re-evaluated and revised, and that emphasis may have to be placed on sanitary measures, repellent materials, and space sprays rather than on residual application of insecticides.

Literature Cited

March, R. B., and R. L. Metcalf. 1949. Laboratory and field studies of DDT-resistant houseflies in southern California. Bul. Calif. State Dept. Agr. 38: 93–101.

[1] Technical hexachloroepoxy-diendomethano octahydronaphthalene, Julius Hyman and Company.

A Life History Study of *Nabis alternatus*

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The damsel-bug *Nabis alternatus* Parshley was found to be the most numerous insect predator within many northern Utah alfalfa fields examined during the midsummer of 1948. *N. alternatus* totaled 41 per cent of the total predators collected in net sweepings, while all Coccinellidae species combined totaled only 25 per cent. The remaining 34 per cent were divided among 10 other insect species and families, each consisting of comparatively small numbers. This population of *N. alternatus* led to a study of its biology in relation to alfalfa pests and plants in northern Utah.

Nabis alternatus specimens were first collected in Cache Valley on May 13, 1948. Males and females from this collection were placed in an oviposition cage. Mating activities began immediately; each copulation lasted from 25 to 30 minutes and mating occurred frequently, especially during the first day. Oviposition began 5 days after copulation was first observed. The eggs were deposited within alfalfa stems, being inserted to their full lengths, leaving only the egg caps visible. These caps rested slightly above the alfalfa stem surface. Eggs were deposited one at a time, usually four to six being laid in a row in the stem. Caged female damsel-bugs laid from 90 to 200 eggs each, averaging 127 eggs per female. The egg laying period averaged 20 days in length, terminating when the ovipositing females died. Egg damage to alfalfa plants was insignificant when compared to feeding damage resulting from activities of the various alfalfa pests which served as damsel-bug prey. Incubation of eggs required 9 days at temperature ranges from 67° to 88° F. Upon hatching, *N. alternatus* nymphs simply pushed the egg caps aside and crawled out of the end of the egg.

Newly hatched *Nabis alternatus* nymphs were reared entirely upon various alfalfa pests, thus indicating their ability to attack and feed on these insects during all five instars, thus enhancing their value as predators of a number of alfalfa insect pests.

Two groups, totaling 106 specimens of newly hatched *Nabis alternatus* nymphs were provided only with pea aphids, *Macrosiphum pisi* (Kalt.) as prey. A total of 39 specimens, or 36 per cent of these damsel-bug nymphs matured within 16 to 30 days. They were furnished 3134 pea aphid specimens as prey, nearly all of which were attacked, fed on, and killed. This was an average of 80 pea aphids per matured damsel-bug nymph.

Two groups of *Nabis alternatus* nymphs, totaling 43 recently hatched specimens, were provided with both nymphal and adult *Lygus elisus* Van Duzee and *L. hesperus* Knight, as their prey. Eight, or 18 per cent of these nymphs matured within 17 to 25 days, being provided a total of 239 lygus bug specimens. The majority of the lygus bugs were attacked and fed on by the nabid nymphs, each averaging 29 lygus bugs per damsel-bug nymph that matured. These matured *N. alternatus* specimens were very robust.

Pea aphids, *Macrosiphum pisi* and lygus bugs, *Lygus hesperus* and *L. elisus*, were furnished on alternate days as insect prey to 15 newly hatched *Nabis alternatus* nymphs. Five of the damsel-bugs reached maturity in 15 to 18 days. Each matured nabid had been furnished 30 aphids and 15 lygus bugs as their prey, most of which met death under the damsel-bug's feeding attack. These matured nabids also were very robust.

Thrips, *Frankliniella moultoni* Hd., *Thrips tabaci* Lind., and *Aeolothrips fasciatus* L., were furnished as prey to 11 recently hatched *Nabis alternatus* nymphs. From these, three damsel-bugs matured in 24 to 27 days. The small size of the thrips specimens prevented accurate counting of numbers attacked by the feeding damsel bugs. However, large numbers of thrips were fed upon and killed.

In order to determine if alfalfa fluid was fed on by *Nabis alternatus* nymphal specimens, 16 newly hatched damsel-bugs were provided only succulent alfalfa. These nymphs refused to feed and all died of starvation within 5 days. On the other hand, nymphs in nearby cages, provided only with insect prey, and given no access to plant fluids during their entire nymphal periods, matured normally. This indicated that *N. alternatus* nymphs mature on the body fluids of insects only, without feeding on plant sap.

Five nymphal instars occurred in each of the rearing experiments. The range of each instar was: first instar 2.6 to 3.6 days; second instar 2.5 to 4.5 days; third instar 2.8 to 6.6 days; fourth instar 2.8 to 9.4 days; fifth instar 5.5 to 8.7 days. Three generations occurred under laboratory conditions during 1948. Overwintering apparently was accomplished by adult specimens, which mated upon their spring emergence.

The tachinid parasite *Leucostoma atra* Tns. was found to be the most numerous enemy of *Nabis alternatus* during the summer of 1948 in the fields of northern Utah. Many parasitised damsel-bug specimens were collected. Their abdomens were extremely enlarged laterally and ventrally by the contained tachinid larvae. The parasitic larvae emerged dorsally from the damsel-bug abdomens, pupated and emerged within 7 to 8 days as small flies. These parasitic flies were identified by Professor H. J. Reinhard. Many damsel-bugs were killed by these flies.

Although damsel-bug nymphs invariably died when attempts were made to rear them on alfalfa weevil larvae, *Phytonomous posticus* (Gyllenhal), adult *Nabis alternatus* specimens were observed to feed on alfalfa weevil larvae, both in the field and in the laboratory. Field studies also revealed adult *N. alternatus* feeding on *Lygus elisus* and *L. hesperus*, *Macrosiphum pisi*, and to be exceptionally voracious on first and second instar grasshopper nymphs. In view of the fact that these bugs, during all active stages, fed on pea aphids, lygus bugs, common alfalfa species of thrips, and attacked various other injurious insects; *N. alternatus* should be considered a definitely beneficial insect in northern Utah alfalfa fields.

Chlorinated Insecticides for Control of Cowpea Insects

PAUL T. RIHERD, *Agricultural Experiment Station, Weslaco, Texas*

In at least a section of the Texas Gulf Coast it is a common opinion among farmers that cowpeas planted in April will not set fruit. Some farmers suggest that the effect of the moon on the plants is responsible for the failure to set fruit. Observations and tests were made to determine the cause for

failure of spring planted cowpeas to set fruit and to determine if the pea weevil could be controlled with early applications of insecticides. Two tests were conducted.

In the first test a planting of peas was divided into eight plats consisting of four rows 150 feet long. At the time the plants began to blossom, an infestation of stinkbugs developed. The infestation consisted of adult *Nezara viridula* and *Euschistus servus* which migrated into the planting. No other suspected insect species was found.

Two insecticidal dusts were tested. Each dust was applied to two plats and one plat left untreated as a check for each plat treated. Two dust mixtures were used, one containing 10 per cent toxaphene–5 per cent chlordan–85 per cent pyrophyllite, and the other 18 per cent toxaphene–5 per cent DDT–77 per cent pyrophyllite. Two applications of the insecticides were made, one June 15, and the other June 25.

To evaluate the effectiveness of the dusts against the stinkbugs which were feeding on the blossom buds and young pods, counts of blossoms and pods were made on 25 feet of row space of each plat before dusting on June 15, and June 25, and also on June 30.

A high degree of control of the stinkbugs was obtained as shown by the large number of pods and blossoms on the treated as compared to the number on the check given in table 1.

Table 1.—The number of blossoms and pods per 25 ft. of row space.

Date	Chlordane Toxaphene	Check	Chlordane Toxaphene	Check
June				
15	4	39	44	49
25	235	63	264	22
30	555	31	639	12
	DDT Toxaphene	Check	DDT Toxaphene	Check
15	0	47	24	19
25	158	76	161	2
30	511	26	391	2

On July 13, 1948, 500 dry peas from each treated plat were gathered and placed in ice cream containers to determine the degree of control of the pea weevil, *Bruchus pisorum*. Not a single matured pod could be found on all the check plats. Only one pea weevil emerged from the 2000 peas gathered and stored from the treated plats.

The second test consisted of four treatments and a check. The plats were six rows 50 feet long replicated three times. The following insecticides were applied at the rate of 25 to 30 pounds per acre on June 15 and June 29, 1948.

(1) Check, no treatment; (2) Sabadilla 10 per cent; (3) rotenone 0.25 per cent, technical piperonyl cyclonene[1] 0.5 per cent, pyrethins 0.05 per cent; (4) pyrethins 0.05 per cent, technical piperonyl cyclonene 0.5 per cent; and (5) rotenone 0.12 per cent, technical piperonyl cyclonene 0.5 per cent. No early infestation of stinkbugs developed, but a light infestation developed after most of the pods were nearly mature. Due to the late development of the stinkbug infestation no blossom and pod counts were made, but a careful general observation indicated that all the treated plats and the check had about the same degree of damage from the stinkbugs. There was a large variation between plats of the number of pea weevils emerging from the stored dry peas, but statistically there was no significant difference between the check and any of the treated plats; however, unlike the test in which the chlorinated insecticides were used there were large numbers of weevils emerged from the stored peas as shown in table 2.

Table 2.—The number of pea weevils emerged from 500 dry peas from each plot.

Dust	Series A	Series B	Series C
1. Check	162	316	1
2. Sabadilla	254	196	3
3. Rotenone 0.25% Tech. piperonyl cyclonene[1] 0.5% Pyrethins 0.05%	59	122	97
4. Pyrethins 0.05% Tech. piperonyl cyclonene 0.5%	26	386	254
5. Rotenone 0.12% Tech. piperonyl cyclonene 0.5%	159	154	92

CONCLUSIONS.—Apparently the failure of spring planted peas in the Gulf Coast area of Texas is due to the feeding of stinkbugs. These tests indicate that both the stinkbugs and the pea weevil can be controlled with chlorinated insecticides; however, the danger of toxic residue would prevent the peas being used for human consumption.

[1] Insecticides containing piperonyl cyclonene was furnished by U. S. Industrial Chemicals Inc.

DDT and Benzene Hexachloride to Control Southern Corn Rootworm

PAUL T. RIHERD, *Agricultural Experiment Station, Weslaco, Texas.*

Severe damage to seedling corn and grain sorghum was caused by the Southern Corn Rootworm along the Gulf Coast of Texas in 1947 and 1948. Large acreages were destroyed. Some fields were replanted as many as three times and many fields were replanted to cotton or other non-susceptible crops after repeated failures to obtain stands of corn or grain sorghum. The 1948 infestation was wide spread but more spotted than the 1947 infestation. There are indications that this pest is becoming more important than in previous years. Seedlings are attacked from the time of germination until they become 6 to 8 inches high. In the later stage, the plants in most cases withstand the feeding of the larvae without being killed; but stunting of growth is evident.

A test to control this pest was conducted on corn of the White Pearl variety that was planted on March 31, 1948. The insecticides tested were 5 per cent DDT—95 per cent pyrophyllite, and 5 per cent gamma benzene hexachloride—95 per cent pyrophyllite. The test consisted of three plats of four rows 168 feet long, and replicated four times. The DDT dust was applied at the rate of 21.32 pounds per acre, and the benzene hexachloride dust at the rate of 24.71 pounds per acre. The dusts were applied with a fan type hand duster by following a

horse-drawn planter with the spout of the duster directed between the covering plows in such a manner as to distribute the dust from the seed to the surface of the soil.

The effects of the insecticides were determined by counting the number of plants on 200 feet of row space from each plat. Records of stands were made on five dates starting when the corn emerged from the soil and continuing until the plants had reached a state of growth where injury from the rootworm was not noticeable. The number of seedlings showing evidence of attack was recorded at each reading.

Benzene hexachloride severely injured the seedlings. The injury was manifested by distortion of the plants, particularly by the swelling of the stems and twisting of the tips. Most of the plants in the benzene hexachloride plats failed to emerge from the soil, and those that did were chlorotic and in most cases died after a short time. In another test where the insecticide was applied above the seed no injury occurred; however, no rootworm infestation developed; therefore no data on the control was secured when applied in this manner.

No injury was evident in the DDT treated plats; in fact, there was some indication of stimulation of plant growth.

Twenty days after planting when the corn had reached a stage of growth that injury was no longer noticeable, the number of plants on the DDT treated plats was significantly greater than on the check plats. The reduction of the number of plants in the benzene hexachloride treated plats was due to the toxicity of the insecticide.

The results are shown in the following table.

Table 1.—Results of application of insecticides on the stand of corn when applied in the soil at the time of planting.

	Mean Number of Plants per 200 ft. of Row 20 Days after Planting
5% DDT	85.25
Check	51.50
5% Benzene hexachloride	9.25
Least mean difference considered significant 1% (99 to 1)	19.59

Aphid Collections at Tallulah, Louisiana, from 1941 to 1947

M. T. Young and G. L. Garrison, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*[1]

Aphis gossypii Glov. was collected from plants other than cotton to determine the plant species infested with this aphid. *A. gossypii* and other aphids were collected from cotton, beginning when the plants were in the two-leaf stage and continuing throughout the growing season, to determine the different species infesting cotton. The collections were made at various places and at irregular intervals. All collections were made in Madison Parish within a radius of 15 miles of Tallulah, La., when time and weather permitted.

The plants, other than cotton, utilized for aphid collections were growing in fields where cotton had been grown the previous season, or on ditch banks, turnrows, and roadsides nearby. *Aphis gossypii* was taken on 21 plants. It was found in more years and on more dates on *Rumex* sp. and *Sonchus asper* (L.) Hill than any other plants. The plants and the dates on which *A. gossypii* was collected are as follows:

Abelmoschus esculentus (L.) Moench.
1943, Sept. 21, 1946, Aug. 16
Bignonia radicans L.
1942, Nov. 19, 1943, Nov. 13
Brassica oleracea L.
1943, Oct. 7
Chaenomeles lagenaria (Loisel.) Koidz.
1941, March 27, 1947, April 9
Chaerophyllum teinturieri Hook.
1943, March 30
Cocculus carolinus (L.) DC.
1942, Nov. 19
Erigeron philadelphicus L.
1942, April 2, 1943, April 2
Geranium carolinianum L.
1943, Feb. 9, April 2
Hibiscus syriacus L.
1945, Nov. 13
Iva ciliata Willd.
1943, March 29, April 13, 1946, April 1
Lamium amplexicaule L.
1942, Nov. 17, 19, 1943, Jan. 25, March 12
Myosurus minimus L.
1941, March 26
Oenothera laciniata Hill
1942, Nov. 19, 1943, March 12
Oenothera speciosa Nutt.
1942, April 13, 1943, March 12, Nov. 6
Plantago virginica L.
1942, April 15
Pyrrhopappus carolinianus (Walt.) DC.
1943, March 29, 1945, March 27
Rose (Hybrid Tea)
1943, Sept. 27
Rumex sp.
1942, April 13, Nov. 19, Dec. 18
1943, Feb. 9, Nov. 6
1947, March 26, April 3, 23
Senecio glabellus Poir.
1943, March 23
Solanum carolinense L.
1943, Aug. 20
Sonchus asper (L.) Hill
1942, Nov. 19, Dec. 18
1943, Oct. 29, Nov. 26
1944, March 1, 1945, April 9
1946, April 3, 1947, April 3

Aphis gossypii is usually present on cotton from the seedling stage until the plants are defoliated by frost; however, in 1942, it was not found on cotton until June 29. Aphids collected from cotton prior to this date in 1942 were determined as *Aphis medicaginis* Koch, *Macrosiphum solanifolii* (Ashm.), and

[1] The work was conducted under the direction of R. C. Gaines. Most of the plants were identified by the Bureau of Plant Industry, Soils and Agricultural Engineering and all aphids were determined by the Division of Insect Identification of the Bureau of Entomology and Plant Quarantine.

Myzus persicae (Sulz). Two species, *Macrosiphum pisi* (Kltb.) and *M. solanifolii*, were collected in April and May only, and *Myzus persicae* in April, May, and June. *Aphis medicaginis* was most often collected in April and May but was also taken in June, July, and October 1945, and June, 1947. *Rhopalosiphum subterraneum* Mason was taken from the leaves of cotton plants in May 1944, and 1947. Aphids collected on cotton and the dates of collections follow:

Aphis gossypii Glover: Collected in the years 1941 to 1947, inclusive, from as early as April 9 (1946) to as late as November 6 (1946).

Aphis medacaginis Koch: Collected 1942 to 1947 inclusive, from as early as April 26, 1946, to as late as October 15, 1947.

Macrosiphum pisi (Kltb.): Collected May 13, 1944 and April 9, 1946.

Macrosiphum solanifolii (Ashm.): Collected as early as April 9, 1946, to as late as May 29, 1947.

Myzus persicae (Sulz.): Collected as early as April 9, 1946 and as late as May 29, 1947.

Rhopalosiphum subterraneum Mason: Collected May 13, 1944 and May 5 and 12, 1947.

Control of Boxelder Bugs

J. A. MUNRO, and R. L. POST, *North Dakota Agr. Expt. Station, Fargo*

Control of the boxelder bug, *Leptocoris trivittatus* (Say) has been augmented by several of the newer insecticides in tests conducted in the Fargo and Northwood vicinities.

The insecticides were applied as water solutions made from emulsion concentrates of DDT, chlordane, toxaphene, lindane and a new nitroparaffin compound known under the code No. CS-645A.

The spray applications were made during the third week of September when counts showed only 12 per cent of the bugs to have reached the adult stage.

The insects were then congregating in masses on the trunks of boxelder trees, weeds and the sunny sides of nearby buildings. They were also invading houses with inadequate screening or poor fitting doors and windows.

Table 1.—Spray applications and results.

INSECTICIDE (EMULSION CONCENTRATES)	SPRAY CONC.	PERCENTAGE KILLED WITHIN		
		1 hr.	24 hrs.	48 hrs.
DDT	1%	—	10	30
DDT	2%	—	60	80
Chlordan	2%	52	80	97
Lindane	2%	70	85	95
Toxaphene	2%	30	85	90
CS-645A	2%	85	80	75[1]
Check		No control		

[1] Following insecticidal applications boxelder bugs invaded the treated areas with all sprays showing residual properties except CS-645A.

The sprays were applied with a knapsack type of sprayer, to the tree trunks and sides of buildings where the insects were most abundant.

Observations on control obtained were made within 1 hour following application and at 24 hour intervals for 2 days thereafter. The spray applications and the control results are summarized in Table 1.

The information augments the prevailing measure, developed by McDaniel (1936), consisting of a spray composed of 1 teaspoonful of a sulfonated higher alcohol[1] to 1 quart of water. An advantage which the newer insecticides possess is that some of them have a continuing toxic action against the insects which invade the treated area.[2]

LITERATURE CITED

McDaniel, E. I. 1936. *Leptocoris trivittatus* (Say) killed by a sulfonated higher alcohol spray. JOUR. ECON. ENT. **29**(6): 1176.

[1] *Dreft.*

[2] Appreciation is expressed to Donald B. Nelson and Norman F. McCalley, student assistants, who aided in this work.

Some Minor Insect Pests of Pecan in Texas[1]

C. B. NICKELS, *U.S.D.A., Agr. Res. Adm., Bureau of Entomology and Plant Quarantine*

During the course of studies to develop control measures for the more important insect pests of pecan in Texas, records were made of other insects that occasionally feed on this host. They are summarized in this note. Nearly all the species in the list were collected on pecan as larvae and then reared to the adult stage in an insectary. The figures in parenthesis refer to the number of records for each species that were accumulated during the years 1918 to 1948.

Infesting buds:

Acrobasis demotella Grote (8)
Acrobasis septentrionella Dyar (3)

Feeding on leaves:

Archips argyrospila (Wlk.) (1)
Catocala angusi Grote (2)
Compsus auricephalus (Say) (2)
Anavitrinella pampinaria (Guen.) (1)
Dichomeris georgiella (Wlk.) (3)
Dichomeris ventrellus (Fitch) (4)
Epitrix parvula Fabr. (16)
Gretchena bolliana (Slingerland) (many)
Panopoda rufimargo (Hbn.) (2)
Schizura leptinoides Grote (7)
Strymon edwardsi (Saund.) (2)
Tetralopa subcanalis (Wlk.) (30)

Infesting shoots:

Acrobasis caryivorella Rag. (many)
Conotrachelus aratus Germ. (3)
Conotrachelus naso Lec. (1)

Infesting twigs and branches:

Lecanium Sp. (many)
Pulvinaria innumerabilis (Rathu.) (few)

Infesting immature nuts:

Platynota rostrana (Wlk.) (1)
Strymon melinus (Hbn.) (1)

[1] Compiled by the author, from his own notes and those of A. I. Fabis, W. C. Pierce, H. S. Adair, and C. C. Pinckney. Determinations were made by the Division of Insect Identifications.

Infesting mature nuts from which larvae of *Curculio caryae* had emerged:

Ephestiodes gilvescentella Rag. (1)
Myelois venipars Dyar (3)

In addition, *Depressaria* sp. was observed to feed on pecan leaves and immature shoots, and *Psilocorsis* sp. was also found on the foliage. A species of *Blastobasis* was reared from immature nuts.

Recent Introductions of Entomophagous Insects into California

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Subsequent to World War II the Division of Biological Control of the University of California Agricultural Experiment Station resumed the importation of entomophagous insects in accordance with the 1931 agreement with the United States Bureau of Entomology and Plant Quarantine and the California State Department of Agriculture. As a consequence, 34 species of entomophagous insects were introduced, propagated, and released during the 3-year period ending June 30, 1949. Additional introductions during this period included 25 species that were not propagated and released. These 25 additional species were not propagated because either the number introduced was inadequate, the sexes were not received synchronously, or the host species were not in a stage suitable for attack or not available in California, being scarce or absent.

In the procurement of entomophagous insects, the Division has had the cooperation of such agencies as the United States Department of Agriculture, Foreign Parasite Laboratory in Europe and Argentina, the Western Province Fruit Research Laboratory of South Africa, the Letaba Estates Parasite Laboratory in the Transvaal, the Board of Agriculture and Forestry of the Territory of Hawaii, and Lingnan University in China. Most of the foreign

Table 1

ENTOMOPHAGOUS SPECIES	COUNTRY OF ORIGIN	HOST PEST
1946		
Chilocorus distigma (Klug)	Transvaal	*Aonidiella aurantii* (Mask.)
Porizon argentinensi Blanch.	Argentina	*Listoderes obliquus* Klug.
Porizon harperi Blanch.	Argentina	*Listoderes obliquus* Klug.
Perisierola emigrata Rohwer	Hawaii	*Pyroderces rileyi* Wilson
Cremasatus flavoorbitalis (Cam.)	Hawaii	*Pyroderces rileyi* Wilson
1947		
Scymnus quadrivattatus Muls.	Western Province	*Pseudococcus* spp.
Exochomus flavipes (Thunb.)	Transvaal	*Pseudococcus* spp.
Pharocymnus exiguus Weise	Transvaal	*Aonidiella aurantii* (Mask.)
Chilocorus angolensis Crotch	Transvaal	*Coccus hesperidum* L.
Chilocorus wahlbergii Muls.	Transvaal	*Aonidiella aurantii* (Mask.)
Lotis neglecta Muls.	Transvaal	*Aonidiella aurantii* (Mask.)
**Lotis nigerrima* Casey	Natal	*Aonidiella aurantii* (Mask.)
Rodolia iceryae Janson	Natal	*Icerya purchasi* Mask.
**Aspidiotiphagus* sp. (near *citrinus*)	Kwangtung Province	*Aonidiella aurantii* (Mask.)
**Aphytis* n. sp. "A" (near *chrysomphali*)	Kwangtung Province	*Aonidiella aurantii* (Mask.)
1948		
**Anagyrus kivuensis* Comp.	Kenya Colony	*Pseudococcus* spp.
Tropidiophryne melvillei Comp.	Kenya Colony	*Pseudococcus* spp.
Aleurodothrips fasciapennis Franklin	Kwangtung Province	*Lepidosaphes* spp.
Aphytis n. sp. "X"	Kwangtung Province	*Lepidosaphes* spp.
Chilocorus negritus (Fabr.)	Kwangtung Province	*Aonidiella aurantii* (Mask.)
Prospaltella sp. "A"	Kwangtung Province	*Lepidosaphes gloverii* Pack.
Scymnus (*Nephus*) sp.	Szechuan Province	*Pseudococcus* spp.
Scymnus (*Pullus*) sp.	Szechuan Province	*Pseudococcus* spp.
Anagyrus sp. (near *fusciventris*)	Szechuan Province	*Pseudococcus maritimus* Erh.
**Casca* n. sp. "C"	Szechuan Province	*Aonidiella aurantii* (Mask.)
Telsimia sp.	Formosa	*Lepidosaphes* spp.
Physcus testaceus Masi.	S. Europe	*Lepidosaphes* spp.
**Aphytis* sp. "C" (near *mytilaspidis*)	S. Europe	*Lepidosaphes* spp.
**Aphytis* sp. "D" (near *diaspidis*)	Egypt	*Parlatoria oleae* (Colvée)
Lotis sp.	Natal	*Aonidiella aurantii* (Mask.)
1949		
**Prospaltella* sp. (near *perniciosi*)	Formosa	*Aonidiella aurantii* (Mask.)
**Trichomathus cyanifrons* (Dalm.)	France	*Gossyparia spuria* (Mod.)
Coccophagus insidiator (Dalm.)	France	*Gossyparia spuria* (Mod.)
Campoplex xanthostoma Grav.	France	*Myelois* sp.

Species marked with an * reproduced for one or more generations after release in the field.

material, however, was collected by Harold Compere, J. Linsley Gressitt, and Y. W. Djou of the Division staff. The identification of much of the material was made by Harold Compere, P. H. Timberlake and H. L. McKenzie.

The introduced species that were propagated and released during the three-year period ending June 30, 1949, are shown in table 1.

The 25 species introduced but not propagated and released are as follows:

Reared from *Pseudococcus* spp. collected on citrus.
Szechuan Province, China
Allotropa sp.
Anagyrus sp.
Clausenia sp.
Coccophagus sp.
Lolodiplosis coccidarum Felt.
Hunan Province
Euryrhopalus sp.
Reared from *Aonidiella aurantii* (Mask.) collected on citrus.
Szechuan Province, China
Anabrolepis sp.
Kwangtung Province, China
Anabrolepis sp.
Casca chinensis How.
Diplosis sp.
Reared from *Chrysomphalus ficus* Ashm. on citrus.
Formosa
Casca n. sp. "B"
Reared from *Parlatoria cinerea* Doane and Haddon on citrus.
Formosa
Coccophagoides abnormicornis Gir.
Reared from *Pseudaonidiella duplex* (Ckll.) on citrus.
Kwangsi Province
Physcus sp. "C"
Reared from *Unaspis citri* (Comst.) on citrus.
Szechuan Province, China
Physcus flaviceps Gir. and Dodd
Reared from *Lepidosaphes beckii* (Newm.) on citrus.
Formosa
Physcus sp. "B"
Reared from *Aspidiotus destructor* Sign. on citrus.
Szechuan Province, China
Comperiella unifasciata Ishii
Kwantung Province, China
Coccidencyrtus sp.
Reared from *Chrysomphalus dictyospermi* (Morg.) on citrus.
Kwangtung Province, China
Casca sp. "D"
Reared from *Aleurocanthus spiniferus* Quaint. on citrus.
Kwangtung Province, China
Amitus sp.
Reared from *Lepidosaphes ulmi* (L.) on elm.
France
Archenomus sp.
Reared from *Gossyparia spuria* on elm.
France
Diplosis sp.
Reared from *Saissetia oleae* (Bern.) on *Markhamia* sp.
Kenya Colony
Encyrtus sp. (near *infelix*)

The successful introduction of living individuals of the species listed above is largely an effect of transportation by air (Gressitt & Flanders, 1949). Successful establishment is under artificial control only to the extent that releases are made in each environmentally distinct host-infested habitat and are sufficient in numbers and properly timed.

LITERATURE CITED

Gressitt, J. Linsley and S. E. Flanders. 1949. New developments in the transport of beneficial insects. JOUR. ECON. ENT. 42: 150.

The Toxicity of Some Substituted Phenyl Benzenesulfonates to the Two-Spotted Spider Mite and Mexican Bean Beetle

E. E. KENAGA, R. W. HUMMER,
The Dow Chemical Co., Midland, Mich.

A number of substituted phenyl benzenesulfonates have been tested against insects (Lauger *et al.* 1944), (Siegler & Gertler 1946), (Frear 1947), (Metcalf 1948). Laboratory test data on some phenyl benzenesulfonates are presented here in order to illustrate the effect of various ring substitutions on the degree and specificity of toxicity to several agricultural pests. Most of these compounds have not appeared previously in the entomological literature.

Field and laboratory test data indicate that the p-chlorophenyl ester of p-chlorobenzenesulfonic acid (known experimentally as K6451) is an outstanding acaracide, being particularly effective against the egg and immature life stages of several species of mites.

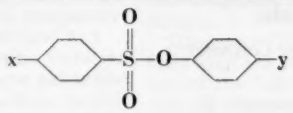
TEST METHODS.—All solid compounds were prepared for testing by ball milling for three hours in water containing a small amount of wetting agent. Liquids and semi-solids were formulated into an emulsifiable concentrate by dissolving them in kerosene containing a suitable emulsifying agent.

Cranberry beans whose primary leaves were infested with the egg and adult life stages of the 2-spotted spider mite, *Tetranychus bimaculatus* Harvey, were dipped momentarily in the insecticidal dispersions. Uninfested beans were similarly dipped and then infested with third instar Mexican bean beetle, *Epilachna varivestis* Muls., larvae. Mortality counts were taken 6 days after application of the insecticide and were corrected for natural mortality. A range of concentrations, usually starting at three pounds of toxicant per hundred gallons, then progressively reducing to 16, 8, 4, 2, etc. ounces, was tested to determine the lowest concentration causing 95 to 100 per cent mortality. This was designated as the minimum 100 per cent lethal dosage.

RESULTS.—The data from tests on twenty-two substituted phenyl benzenesulfonates are summarized in table 1. These compounds are relatively ineffective against the two-spotted spider mite adult. Against the mite egg the following decreasing order of toxicity may be observed: 4-chlorophenyl ester of 4-chlorobenzenesulfonic acid > 4-bromophenyl ester of 4-chlorobenzenesulfonic acid > 4-chlorophenyl ester of 4-bromobenzenesulfonic acid > remaining compounds. Against the Mexican bean beetle larva the following decreasing order of toxicity occurs:

Paid Paper.

Table 1.—The toxicity of some phenyl esters of benzenesulfonic acid to the two-spotted spider mite and Mexican bean beetle.



RING SUBSTITUTION		MINIMUM 100 PER CENT LETHAL DOSAGE IN LBS. PER 100 GALLONS		
		Two-Spotted Spider Mite		Mexican Bean Beetle
x	y	Adult	Egg	Larva
unsubstituted	unsubstituted	>3.0	>3.0	>3.0
unsubstituted	4-chloro	3.0	3.0	3.0
4-chloro	unsubstituted	>3.0	3.0	3.0
4-chloro	4-chloro	>3.0	0.06	0.5
4-chloro	2,4-dichloro	>3.0	>3.0	>3.0
*4-chloro	2,4,5-trichloro	>3.0	>3.0	>3.0
*4-chloro	2,4,6-trichloro	>3.0	>3.0	>3.0
*4-chloro	tetrachloro	>3.0	>3.0	>3.0
*4-chloro	pentachloro	>3.0	>3.0	3.0
*4-chloro	4-bromo	>3.0	0.25	1.0
*4-chloro	4-methyl	>3.0	>3.0	>3.0
*4-chloro	2-sec. butyl	>3.0	3.0	3.0
*4-chloro	4-tert. butyl	>3.0	>3.0	>3.0
*4-chloro	2-allyl	>1.0	>1.0	>1.0
*4-chloro	2-methallyl	>3.0	>3.0	3.0
*4-chloro	4-methoxy	>3.0	>3.0	1.0
*4-chloro	4-nitro	>3.0	>3.0	>3.0
*4-chloro	2-cyclohexyl-4,6-dinitro	>1.0	>1.0	>1.0
*4-chloro	2-phenyl	3.0	>3.0	>3.0
*4-bromo	4-chloro	>3.0	0.5	2.0
*4-bromo	4-bromo	>3.0	>0.5	>3.0
*3-nitro	4-chloro	>3.0	>3.0	>3.0

> =greater than.
* =new compounds

4-chlorophenyl ester of 4-chlorobenzenesulfonic acid>4-bromophenyl ester of 4-chlorobenzenesulfonic acid=4-methoxyphenyl ester of 4-chlorobenzenesulfonic acid>4-chlorophenyl ester of 4-bromobenzenesulfonic acid>remaining compounds.

SUMMARY AND CONCLUSIONS.—Twenty-two substituted phenyl benzenesulfonates were tested against the egg and adult life stages of the two-spotted spider mite and the larva of the Mexican bean beetle. The following relationships of chemical structure to insecticidal activity were observed:

1. Optimum mite ovicidal activity occurred where both rings were substituted with chlorine in the para position (4-chlorophenyl ester of 4-chlorobenzenesulfonic acid). This activity decreased when one chlorine was removed or replaced with bromine and decreased even more when both chlorines were removed or replaced with bromine at the concentrations tested. Compounds containing other substitutions in this series were relatively ineffective.

2. The phenyl benzenesulfonates were not sufficiently toxic to adult mites to make possible an insecticidal-chemical structure correlation study.

3. The toxicity of the phenyl benzenesulfonates to the Mexican bean beetle larva follows the same relationship of structure to activity as is shown against the mite egg. Toxicity was also obtained with the 4-methoxy phenyl ester of 4-chlorobenzenesulfonic acid.

LITERATURE CITED

Frear, D. E. H. 1947. A catalogue of insecticides and fungicides. Vol. I. Chemical insecticides. Chronica Botanica Co., Waltham, Mass.

Lauger, P., H. Martin and P. Muller. 1944. The constitution and toxic effect of botanicals and new synthetic insecticides. Helv. Chim. Acta. **27.** Translated by Geigy Co., New York (1945).

Metcalf, R. L. 1948. Acaracidal properties of organic compounds related to DDT. JOUR. ECON. ENT. **41**(4): 875–82.

Siegler, E. H. and S. I. Gertler. 1946. Toxicity of aromatic esters of p-toluenesulfonic acid to codling moth larvae. JOUR. ECON. ENT. 39(5): 674.

Siegler, E. H. and S. I. Gertler. 1946. Toxicity of aromatic esters of benzenesulfonic acid to codling moth larvae. JOUR. ECON. ENT. **39**(5): 662.

The Toxicity of Some Bis(Substituted phenoxy) Methanes to the Two-Spotted Spider Mite and Mexican Bean Beetle

E. E. KENAGA, *The Dow Chemical Company*
Midland, Michigan

The search for acaracides to complement the insect killing properties of DDT and some other chlorinated hydrocarbons has led to the discovery of bis(4-chlorophenoxy) methane[1] (Moyle 1942). Laboratory tests on analogues of bis(4-chlorophenoxy)-methane are presented here in order to illustrate the effect of various ring substitutions on the degree and specificity of insect and mite toxicity.

Outstanding properties of bis(4-chlorophenoxy)-methane are mite ovicidal action (Jeppson, 1946, 1948) and residual toxicity to European red mite. This compound is low in toxicity to warm blooded animals and low in handling hazards (Spencer *et al.* 1949).

TEST METHODS.—All solid compounds were prepared for testing by ball milling for three hours in water containing a small amount of wetting agent. Liquids and semi-solids were formulated into an emulsifiable concentrate by dissolving them in refined kerosene containing a suitable emulsifying agent.

Cranberry beans whose primary leaves were infested with the egg and adult life stages of the 2-spotted spider mite, *Tetranychus bimaculatus* Harvey, were dipped momentarily in the insecticidal dispersions. Uninfested beans were similarly dipped and allowed to dry and were then infested with third instar Mexican bean beetle, *Epilachna varivestis* Muls., larvae. Mortality counts were taken 6 days after application of the insecticide and were corrected for natural mortality. A range of concentrations, usually starting at three pounds of toxicant per hundred gallons, then progressively reducing to 16, 8, 4, 2, etc. ounces was tested to determine the lowest concentration causing 95 to 100 per cent mortality. This last concentration was designated as the minimum 100 per cent lethal dosage.

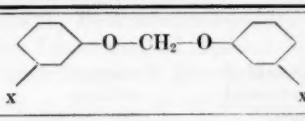
RESULTS.—The data from tests on 24 bis(phenoxy)methanes are summarized in table 1. From these results the following diminishing order of toxicity may be observed on the two spotted spider mite adult: bis(2-allyl-6-chlorophenoxy)methane > bis (2-allyl-4-chlorophenoxy) methane > bis (4-chlorophenoxy)methane = bis(2-allyl-4-methoxyphenoxy) methane = bis (2-allyl-4-methylphenoxy)methane > remaining compounds. Against the two-spotted spider mite egg bis(4-chlorophenoxy)methane is the only toxicant which is significantly effective. Against Mexican bean beetle larva the following diminishing order of toxicity may be observed: bis (2-allyl-4-methoxyphenoxy) methane > bis (2-allylphenoxy)methane = bis(2-allyl-6-chlorophenoxy)-methane > bis (4-chlorophenoxy) methane = bis (4-bromophenoxy)-methane = bis (2-allyl-4-chlorophenoxy)methane = bis(2-sec. butylphenoxy)methane > remaining compounds. The bis(polychlorophenoxy)methanes are ineffective against all life stages tests.

SUMMARY AND CONCLUSIONS.—Twenty-four bis-(phenoxy)methanes were tested against eggs and adults of the two-spotted spider mite and larvae of the Mexican bean beetle. The following relationship of chemical structure to insecticidal activity was observed:

1. Bis(4-chlorophenoxy)methane exhibits good toxicity against all life stages of the organisms tested and is particularly specific to mite eggs. Thus the bis 4-chloro-substitution seems to be most advantageous in this series of compounds.

2. Compounds containing the bis 2-allyl ring substitution either in combination with other ring substitutions or alone appear to impart to these compounds a high order of toxicity to the 2-spotted spider mite adult and to the Mexican bean beetle larva.

Table 1.—The toxicity to the 2-spotted spider mite and the Mexican bean beetle of some bis-(substituted phenoxy) methanes.



RING SUBSTITUTION x	MINIMUM 100% LETHAL DOSAGE: LBS. TOXICANT PER 100 GALLONS		
	2 Spotted Spider Mite		Mexican Bean Beetle
	Adult	Egg	Larva
unsubstituted	3.0	>3.0	>3.0
2-chloro	2.0	3.0	>1.0
4-chloro	1.0	0.25	0.5
2,4-dichloro	>3.0	>1.0	>3.0
*2,4,5-trichloro	>3.0	>1.0	>3.0
*2,4,6-trichloro	>3.0	>3.0	>3.0
*2,3,4,6-tetrachloro	>3.0	>3.0	>3.0
*pentachloro	>3.0	>3.0	>3.0
4-bromo	>1.0	3.0	0.5
4-nitro	>2.0	—	>2.0
*2-sec. butyl	3.0	3.0	0.5
x-tert. octyl	>2.0	—	>2.0
*2 allyl	3.0	3.0	0.25
*4-methoxy	>3.0	>3.0	1.0
*2,6-dimethoxy	>3.0	>3.0	3.0
*4-n-butoxy	>1.0	>1.0	>1.0
*2-chloro, 6-methyl	2.0	>2.0	>3.0
*2-chloro, 4-sec. butyl	>1.0	>1.0	>1.0
*4-chloro, 2-methyl	>3.0	>3.0	>3.0
*4-chloro, 2-sec. butyl	>1.0	>1.0	>1.0
*4-chloro, 2-allyl	0.5	>1.0	0.5
*6-chloro, 2-allyl	0.25	>1.0	0.25
*2-allyl, 4-methyl	1.0	>1.0	>1.0
*2-allyl, 4-methoxy	1.0	>1.0	0.12

> = greater than.
* = new compounds.

LITERATURE CITED

Moyle, C. L. 1942. Insecticide. U. S. Patent 2,330,234. Issued Sept. 28, 1943.

Jeppson, L. R. 1946. Di(4-chlorophenoxy)methane for the control of the citrus red mite. JOUR. ECON. ENT. 39(6): 813.

Jeppson, L. R. 1948. Progress shown in the control of citrus red mite. Down to Earth 3(4): 2–4.

Spencer, H. C., V. K. Rowe, E. M. Adams, and D. D. Irish. 1949. Toxicological studies on the new miticide bis(p-chlorophenoxy)-methane. Arch. Ind. Hyg. and Occup. Med.

[1] Neotran.

The Toxicity of Some Substituted Phenyl Benzoates to the Two-Spotted Spider Mite and Mexican Bean Beetle

E. E. KENAGA, *The Dow Chemical Co., Midland, Mich.*

Some of the phenyl benzoates are known as lousicides, repellents and chigger killers. (U.S.D.A., B.E.P.Q., E-733, 1947), (Snyder and Morton, 1946). Other phenyl benzoates have been tested against various insects (Frear, 1947). Laboratory tests on some phenyl benzoates on several agricultural pests are presented here in order to illustrate the effect of ring substitution on the degree and specificity of insect and mite toxicity

TEST METHODS.—All solid compounds were prepared for testing by ball milling for three hours in water containing a small amount of wetting agent. Liquids and semi-solids were formulated into an emulsifiable concentrate by dissolving them in refined kerosene containing a suitable emulsifying agent.

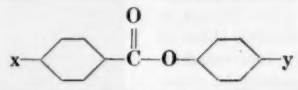
Cranberry beans whose primary leaves were infested with the egg and adult life stages of the 2-spotted spider mite, *Tetranychus bimaculatus* Harvey, were dipped momentarily in the insecticidal dispersions. Uninfested beans were similarly dipped and then infested with third instar Mexican bean beetle, *Epilachna varivestis* Muls., larvae. Mortality counts were taken 6 days after application of the insecticide and were corrected for natural mortality. A range of concentrations, usually starting at 8 pounds of toxicant per hundred gallons, then progressively reducing to 16, 8, 4, 2, etc. ounces, was tested to determine the lowest concentration causing 95 to 100 per cent mortality. This last concentration was designated as the minimum 100 per cent lethal dosage.

RESULTS.—The data from tests on twenty phenyl benzoates are summarized in table 1. From these figures the following diminishing order of toxicity may be observed on the two-spotted spider mite adult: 2-sec.-butylphenyl ester of 4-chlorobenzoic acid > 3-methylphenyl ester of 3-chlorobenzoic acid = 2-allylphenyl ester 4-chlorobenzoic acid > 4-chlorophenyl ester of 4-chlorobenzoic acid > remaining compounds. The following order of diminishing toxicity may be observed on the two-spotted spider mite egg: 4-chlorophenyl ester of 4-chlorobenzoic acid > 4-sec.-butylphenyl ester of 4-chlorobenzoic acid = 4-chloro-2-methylphenyl ester of benzoic acid > 4-chlorophenyl ester of benzoic acid = 3-methylphenyl ester of 3-chlorobenzoic acid > the remaining compounds. None of the compounds tested were significantly effective against the Mexican bean beetle larva.

SUMMARY AND CONCLUSIONS.—Twenty phenyl benzoates were tested against the egg and adult life stages of the two-spotted spider mite and the larva of the Mexican bean beetle. The following relationships of chemical structure to insecticidal activity were observed:

1. Optimum acaricidal activity occurred where one or more rings were substituted with chlorine in the para position. Ovicidal properties were greatest where both rings were substituted with chlorine in

Table 1.—The toxicity of some phenyl benzoates to the two-spotted spider mite and Mexican bean beetle.



RING SUBSTITUTION		MINIMUM 100 PER CENT LETHAL DOSAGES IN LBS. PER 100 GALLONS		
		2-Spotted Spider Mite		Mexican Bean Beetle
x	y	Adult	Egg	Larva
unsubstituted	unsubstituted	>3.0	>3.0	>3.0
unsubstituted	4-chloro	>1.0	3.0	>1.0
unsubstituted	2,4-dichloro	>3.0	>3.0	>3.0
unsubstituted	2,4,6-trichloro	>3.0	>3.0	>3.0
unsubstituted	pentachloro	>3.0	>3.0	>3.0
*unsubstituted	2-allyl, 6-sec. butyl	>3.0	>3.0	>3.0
*unsubstituted	2-chloro, 6-methyl	>3.0	>3.0	>3.0
unsubstituted	4-chloro, 2-methyl	>3.0	1.0	>3.0
*2-chloro	3-methyl	>1.0	>1.0	>1.0
*3-chloro	3-methyl	2.0	3.0	>3.0
4-chloro	unsubstituted	>3.0	>3.0	>3.0
*4-chloro	4-chloro	3.0	0.5	>3.0
*4-chloro	2,4,5-trichloro	>3.0	>3.0	>3.0
*4-chloro	3-methyl	>3.0	>3.0	>3.0
*4-chloro	4-methyl	>3.0	>3.0	>3.0
*4-chloro	2-sec. butyl	0.5	>3.0	>3.0
*4-chloro	4-sec. butyl	>3.0	1.0	>3.0
*4-chloro	2-allyl	2.0	>1.0	>3.0
*2,5-dichloro	4-chloro	>3.0	>3.0	>3.0

> = greater than.
* = new compounds.

the para positions (4-chlorophenyl ester of 4-chlorobenzoic acid).

2. The phenyl benzoates investigated were not sufficiently toxic to the Mexican bean beetle larva to make possible a correlation of insecticidal activity and chemical structure.

LITERATURE CITED

Frear, D. E. H. 1947. A catalogue of insecticides and fungicides. Vol. I. Chronica Botanica Co., Waltham, Mass.

Snyder, F. M. and F. A. Morton. 1946. Materials as effective as benzyl benzoate for impregnating clothes against chiggers. JOUR. ECON. ENT. 9: 385–6.

United States Bureau of Entomology and Plant Quarantine. 1947. Results of screening tests with materials evaluated as insecticides, miticides and repellents at the Orlando, Florida, Laboratory from April 1942 to April 1947. U.S.D.A., B.E.P.Q., **E-733.**

OBITUARY

Jesse Mathews Robinson, 1889-1949

Jesse Mathews Robinson, professor of zoology and entomology and department head at Alabama Polytechnic Institute, died at his home in Auburn Saturday night, August 27, 1949.

Professor Robinson, who served Alabama Polytechnic Institute for 30 years, had spent most of the day preparing for graduation exercises. He had returned to his home about 9 p.m. and had retired when he complained of feeling ill and died of a heart attack at 11 p.m.

The professor, known as "Robby" to hundreds of Auburn graduates and his colleagues, came to Auburn in 1919 as assistant professor of zoology and entomology. Two years later he was appointed associate professor, and for five years he served as acting head of his department. In 1929 he was appointed head and professor.

Professor Robinson served in many extra capacities on the campus. For a number of years he was in charge of all faculty processionals, including those of graduation exercises. He was greatly interested in students, particularly those who planned to enter the practice of medicine or entomology. Throughout practically his entire residence at Auburn he was faculty advisor for the Inter-Fraternity Council.

Professor Robinson was born in Higginsport, Ohio, January 30, 1889. He received his bachelor's degree from Miami University, Oxford, Ohio, in 1911. For five years he was a teacher and principal in the schools of Ohio. In 1915 and 1916 he was a graduate assistant at Ohio State University, Columbus, where he received his master's degree in entomology.

For two years he did extension work in entomology in North Carolina and Tennessee for the U. S. Bureau of Entomology.

In addition to his many activities as a teacher and administrator, Professor Robinson did research on control of boll weevil and other cotton insects. In this capacity he was leader of a long-time project studying boll weevil control in relation to soil fertility and productivity of cotton. Published results of this research have appeared in the JOURNAL OF ECONOMIC ENTOMOLOGY and Experiment Station publications. Professor Robinson also conducted research on the biology of the banded cucumber beetle, *Diabrotica balteata* Lec., and of the vegetable weevil, *Listroderes obliquus* Klug.

He was a member of many professional organizations and societies, including the American Association of Economic Entomologists, Entomological Society of America, Eugenics Research Association,

Genetics Association, American Association for the Advancement of Science, Phi Kappa Phi, Gamma Sigma Delta, and Alpha Gamma Rho. He was a past chairman of the Cotton States Branch of the American Association of Economic Entomologists and also president of the Alabama Academy of Science. He was a member of the Ohio Academy of Science, and for several years was administrator for the U. S. Package and Queen Bee Shippers Association.

Professor Robinson was an active officer and member of the First Presbyterian Church at Auburn, serving as elder, and as chairman of the music and student affairs committees. He was a charter number of the Auburn Rotary Club.

He is survived by his widow, Mrs. Lena May Robinson, and a niece, Miss Kathleen Johnson, who has resided with the Robinsons for several years.

JOURNAL OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists

Vol. 42 December, 1949 No. 6

Editorials

Several inquiries as to the source of the editorial on "The need for an annual Review of Entomology" printed in the October number of the JOURNAL have been received, along with very favorable comments on the editorial from members who have read it, remind the editor that he failed to append the name of the author.

The author is Dr. Leo Kartmann, at present in the School of Hygiene and Public Health of Johns Hopkins University, in Baltimore, Maryland, and the favorable comments may be sent directly to Dr. Kartmann.

Think Like a Malaria Mosquito

Doctor G. E. Vincent, a former president of the Rockefeller Foundation one time said that "a malaria fighter must learn to think like the mosquito he is fighting" before he fights well. He observed that too many advocates of systems for controlling this dread disease base their operations on limited views of the behavior of the mosquitoes concerned. Instead he urged the necessity of making the measure fit the specific local condition. The way to do this best is to know every possible detail about the pest concerned and have that information current for each condition. The principle involved is applicable to all aspects of applied entomology.

Like all wars, that against noxious insects is a series of local engagements each with its own unique aspects. One thing the several battles have in common is a need for up-to-the-minute news about the strength, disposition and fighting potential of the enemy at the time the battle is joined. General information is outmoded and when employed results in half-measures and broken faith with growers and others we are bound to protect.

Intelligence of the most usable sort comes direct from the insects themselves. Some investigators spend their full time asking insects pertinent questions that lead to their control. Every applied entomologist should spend as much time as he can afford doing the same thing. By this means information may be kept up to date.

A second source of valuable intelligence is that of fundamental nature that has been gathered by observers and published in numerous journals, bulletins and monographs. Unfortunately for many of those in the front lines of the battles, much of this fundamental information is not available because of lack of libraries and time for assembling it. Doctor Leo Kartmann has called our attention to this fact in an editorial in the October issue of this JOURNAL. He has gone further and has suggested a workable remedy for the situation in the form of an annual review. A critical review of the fundamentals would go far toward keeping the most important cog in fighting machine properly meshed.

If we kept constantly in mind the necessity for knowing what the insect "thinks" about by direct questioning and through fundamental principles gleaned from observations of others, efforts toward control would be less stereotyped and more applicable to conditions. Let us read the books the insects write rather than insist that they read ours.

WILLIAM R. HORSFALL
Department of Entomology
University of Illinois

Report of the Committees on Consolidation Submitted at the Tampa Meetings

The committees appointed by the Entomological Society of America and the American Association of Economic Entomologists to consider the possible consolidation of the two organizations have submitted tentative plans to their respective Executive Committees. These plans are in agreement in many respects. Both agree that consolidation is desirable. Essential points of agreement are:

Name: Entomological Society of America.
Membership: One main class of voting members.
Publications: The Annals of the Entomological Society of America and the JOURNAL OF ECONOMIC ENTOMOLOGY will be continued and that provision be made for a monthly news bulletin.
Executive Officer: A full-time paid non-voting executive officer to carry out the organization's policies and to have charge of its business affairs.
Dues: Substantial increase in dues above those for either present organization, to provide for the salaried executive officer and other services, in order that the needs of all entomology may be adequately met.
Branches and Sections: The principle of geographic and subject matter groups to be maintained.

The Entomological Society of America and the American Association of Economic Entomologists have continued their two committees as a joint committee to study the matter further and propose a form of organization in which all major entomological interests will have representation and opportunity for expression.

The proposal as it may be approved by the Executive Committee of both organizations will be presented to the entire membership of each organization for study and vote by mail ballot.

For the Entomological Society of America.

E. G. LINSLEY
C. E. MICKEL
C. F. W. MUESEBECK, *Chairman*

For the American Association of Economic Entomologists.

H. M. HARRIS
J. L. HORSFALL
B. A. PORTER, *Chairman*

December 13, 1949

NOTES

THE ROCKY MOUNTAIN CONFERENCE OF ENTOMOLOGISTS

The twentieth Rocky Mountain Conference of Entomologists was held at the Cameron Pass 4H Club Camp Aug. 16 to 20, 1949. The camp is located in the mountains at an altitude of 9,500 feet, about 85 miles west of Fort Collins, Colo. Many of the visiting entomologists were accompanied by members of their families. A total of 109, representing 17 states, enjoyed the conference and outing. The following were directly interested in entomology:

A. M. Boyce, A. J. Flebut, A. Fullmer Allred, Lorin Anderson, George W. Coffman, Leslie B. Daniels, Louis G. Davis, Bob Hamman, John L. Hoerner, Geo. M. List, Joe Mattson, Sam C. McCampbell, Mrs. J. Ross McLaughlin, Gordon T. Mickle, J. H. Newton, Miriam Palmer, P. A. Ray, Tom Snipes, John R. Stuntz, T. O. Thatcher, C. E. Titensor, Richard I. Washburn, Don Weeks, Noel D. Wygant, E. N. Woodbury, W. P. Hayes, O. W. Park, Paul A. Dahm, A. L. Goodrich, Bert A. Zuhl, Fred W. Fletcher, W. F. Cherry, F. L. Harden, Clarence A. Sooter, Ephriam Hixson, Joe Pappas, E. I. Kostal, R. J. Walstrom, B. H. Wilford, J. G. Sanders, T. H. Parks, J. W. Gibson, D. E. Howell, S. W. Clark, F. A. Holmes, Geo. I. Reeves, T. R. Robb.

During the period eight sessions were held for informal discussions, the programs for the most part being made up after the group assembled. For recreation, other than just relaxing, there were insect collecting, fishing, mountain climbing, horsehoe pitching, miniature golf, and especially for the ladies, bridge, meals without cooking, and watching the men wash the dishes.

The following were the more important discussion topics with the names of the leaders:

Encephalitis Investigations in the Missouri River Valley; C. A. Sooter
The Oriental Fruit Fly in Hawaii; A. M. Boyce
Boundaries of the Pacific Slope Branch and other Branches of the American Association of Economic Entomologists; A. J. Flebut and A. M. Boyce
Plant Quarantine Inspection Policies; E. Kostal
Insect Vector and Virus Disease Relationships; L. B. Daniels
The Dutch Elm Disease and Insect Vectors; B. H. Wilford
Peach Mosaic Control in Colorado; Lorin Anderson
Wheat Mosaic; Ephriam Hixson
Quick Decline of Citrus; A. M. Boyce
Fly Control and Residues in Milk; D. E. Howell, Ephriam Hixon, Paul Dahm, A. M. Boyce, T. H. Parks and T. R. Robb
Chlorinated Hydrocarbons in Meats and Milk; E. N. Woodbury and Paul Dahm
The Control of Sheep Ticks in Wyoming; T. R. Robb
Horticultural and Vegetable Crop Insects. Symposium; T. H. Parks Leader.
- Orchard Insects in Colorado; J. H. Newton
- The Cherry Fruit Worm, *Grapholithia packardi* Zell.; J. L. Hoerner
- Bean Beetle Control; T. H. Parks and Geo. M. List
- Onion Thrips Control Results; J. L. Hoerner

Corn Ear Worm Control
Melon Aphis Control
Forest Insect Problems in the Rocky Mountain area; Noel Wygant
Is There an Over-use of Insecticides; T. O. Thatcher
Field and Forage Crop Insects. Symposium; Ephriam Hixson Leader
Research Work Under Way in Nebraska on Alfalfa Seed Production; Joe Pappas
Field and Forage Crop Problems in Ohio; T. H. Parks
Research Work in Kansas; Paul Dahm
Alfalfa Weevil Control Tests; J. H. Newton
The 1949 Grasshopper Control Program; L. G. Davis

The Officers elected for 1950 were:
Chairman—L. B. Daniels
Vice-Chairman—T. R. Robb
Secretary—Geo. M. List
Vice-Secretary—Gordon Mickle
Treasurer—J. L. Hoerner

GEO. M. LIST, *Secretary*

The following members and visitors registered for the meeting:—

Norman B. Akesson
C. C. Alexander
M. W. Allen
Lauren D. Anderson
L. E. Anderson
H. M. Armitage
E. L. Atkins
Stanley F. Bailey
Harvey M. Bales
C. O. Barnard
Roy R. Bannon
Martin M. Barnes
Daniel E. Bannell
F. Ray Barron
Liston A. Bascom
R. G. Beasley
Fred C. Bishopp
C. J. Boissonou
G. T. Bottger
A. M. Boyce
Ralph L. Brant
Art Bronson
Frank A. Brown
Thomas Burnett
W. H. Burnside
J. E. Bussart
Roy E. Campbell
G. E. Carman
S. W. Clark
C. P. Clausen
E. H. Coe
George W. Coffman
F. B. Cash
John F. Cook
C. E. Cooley
A. J. Cox
A. W. Cressman
H. H. Crowell
James B. Curtis
R. H. Daehnert
Paul DeBach
D. W. Dean
Edward Degginger
D. G. Denning
R. C. Dickson
E. J. Dietrick
S. C. Dorman
J. R. Douglas
Charles E. Duggan
Clark O. Eads
Walter Ebeling
John C. Elmore
Larry W. Erb
A. M. Esberg
Chas. O. Esselbaugh
John R. Eyer
Jack E. Fahey
L. R. Faulkner
Curtis Ferris
Stanley E. Flanders
E. J. Flebut
Carl Fletcher
R. A. Flock
L. W. Ford
Warren T. Frazier
J. H. Freitag
Roy F. Fritz
Marvin H. Frost
L. W. Garner
A. F. Geib
L. G. Gentner
Henry Greer
N. F. Hurdman
Karl Hassler
L. S. Hitchner
O. B. Hitchcock
R. A. Hoffman
W. M. Hoskins
Samual B. Hough
K. E. Hughes
H. A. Hunt
R. W. Hunt
Milton Irvine
R. N. Jefferson
Lee R. Jeppson
Floyd A. Johnson
Richard Johnson
Wm. L. Jonson
M. P. Jones
G. B. Jordan
G. H. Kaloostian
A. F. Kirkpatrick
E. F. Knipling
G. F. Knowlton
R. A. Lamouce
W. H. Lange
Truman E. Laningham
J. L. Lauerdale
L. L. Lewallen
David L. Lindgren
John A. Lindsay
A. W. Lindquist
Ed Littooy
Erwin Loeffler
Stuart R. Lyon
W. E. McCauley
L. D. McCorkindale
Dean E. McCrory
F. B. McLane
Neil A. MacLean
Guy F. MacLeod
George E. Mack
J. Marshall Magner
Chas. H. Mahoney
Ralph B. March
Chas. H. Martin
David Martin
Kenneth E. Maxwell
E. L. Mayer
Paul Mayfield
W. T. Mendenhall
Robt. L. Metcalf
Ernest G. Meyers
Jack Millen
Roy E. Miller
Y. H. Montgomery
J. B. Moore
William Moore
H. E. Morrison
Don C. Mote
Wm. E. Murphy
Edwin J. O'Neal
H. O. Parrent
D. D. Penny
R. E. Pfadt
J. K. Primm
A. Earl Pritchard
Harold T. Reynolds
Harry H. Roberts
J. N. Roney
Louis W. Sheets
Howard B. Sheldon
W. A. Simanton
Russell E. Siverly
Gordon F. Smith
Harry S. Smith
Jack R. Smith
L. G. Smith
Leslie M. Smith
B. Thomas Snipes
C. H. Starker
W. A. Stevenson
Stanley W. Strew
A. F. Swain
John E. Swift
Ted W. Swift
M. C. Swingle
Arlo Thomas
W. W. Thomas
B. G. Thompson
W. R. Thompson
Guy F. Toland
James H. Turner
E. L. Wampler
Robert M. Warner
Carl J. Weinman
M. F. Wharton
J. Allen White
Joseph Wilcox
John N. Williams
W. R. Wood

Total attendance 275

PROPOSED ADDITIONS TO AND CHANGES IN LIST OF COMMON NAMES OF INSECTS

The Committee on Common Names of Insects has given consideration to common names proposed for 47 insects not at present included in the official list of common names and to proposed changes in 6 of the names previously adopted. In accordance with the suggestion made by the Committee at the sixtieth annual meeting of the Association held at New York City in December 1948, the names under consideration are hereby being brought to the attention of the entire membership of the Association.

Each of the proposals listed below has received the votes of seven or more members of the Committee necessary for adoption. Members of the Association having valid objections to any of the new names or changes selected are urged to communicate immediately with the chairman of this Committee, giving their reasons as to why they do not consider a proposed name or change acceptable. Objections received within thirty days of the date this issue of the Journal of Economic Entomology is distributed will be given consideration by the Committee. Comments should be addressed to G. J. Haeussler, Bureau of Entomology & Plant Quarantine, Washington 25, D. C.

PROPOSED ADDITIONS TO THE OFFICIAL LIST OF APPROVED COMMON NAMES

Scientific names	*Common names*
Anaticola anseris (L.)	*slender goose louse*
Anuraphis viburniphila (Patch)	viburnum aphid
Aphis abbreviata (Patch)	buckthorn aphid
Aristotelia fragariae (Busck)	strawberry crown miner
Asterolecanium variolosum (Ratz.)	golden oak scale
Bovicola caprae (Gurlt)	goat biting louse
Bovicola limbatus (Gerv.)	angora goat biting louse
Bovicola ovis (L.)	sheep biting louse
Cyclocephala borealis Arrow	northern masked chafer
Cyclocephala immaculata (Oliv.)	southern masked chafer
Dermodex folliculorum (Simon)	follicle mite
Dissosteira longipennis (Thomas)	long-winged plains grasshopper
Drepanaphis acerifoliae (Thos.)	painted maple aphid
Eriophyes thujae Gar.	tip-dwarf mite
Eutrombidium trigonum (Herm.)	red grasshopper mite
Geshna cannalis (Quaint.)	lesser canna leaf roller
Goniodes numidae Mjoberg	guinea feather louse
Gyropus ovalis Nitzsch	oval guinea pig louse
Haematopinus quadripertusus Fah.	cattle tail louse
Hulstia undulatella (Clem.)	sugar-beet crown borer
Itonida citrulli Felt	cucurbit midge
Lasioptera murtfeldtiana Felt	sunflower seed midge
Lecanium fletcheri (Skll.)	Fletcher scale
Limax maximus L.	spotted garden slug
Linognathus setosus (Olf.)	dog sucking louse
Linognathus stenopsis (Burm.)	goat sucking louse
Lipeurus numidae (Denny)	slender guinea louse
Oxylipeurus polytrapezius (Burm.)	slender turkey louse
Phalonia rutilana (Hüb.)	pale juniper webworm
Phyllobius intrusus Kono	arborvitae weevil
Physokermes piceae (Schr.)	spruce bud scale
Pogonomyrmex barbatus var. *molefaciens* Buckley	Texas harvester ant
Polyphylla ruficellis var. *perverse* Csy.	northwestern June beetle
Polyplax spinulosa (Burm.)	spined rat louse
Prodenia praefica Grote	western yellow-striped armyworm
Rhodobaenus tredecimpunctatus (Ill.)	cocklebur weevil
Sipha flava (Forbes)	yellow sugarcane aphid
Solenopsis saevissima v. *richteri* Forel	imported fire ant
Solubea pugnax (F.)	rice stink bug
Sternechus paludatus (Casey)	bean stalk weevil
Suleima helianthana (Riley)	sunflower budworm
Tholeria reversalis (Guen.)	genista caterpillar
Tinola walsinghami Busck	plaster bagworm
Trichodectes canis (De Geer)	dog biting louse
Trinoton anserinum (F.)	goose body louse
Typhlocyba tenerrima H. S.	bramble leafhopper
Zonosemata electa (Say)	pepper maggot

PROPOSED CHANGES IN PRESENT APPROVED COMMON NAMES

Scientific names	*Common names*	*To replace*
Epicauta cinerea (Forst.)	clematis blister beetle	gray blister beetle
Harrisina brillians B. & McD.	western grape leaf skeletonizer	western grape skeletonizer
Melittia cucurbitae (Harr.)	squash vine borer	squash borer
Nosopsyllus fasciatus (Bosc.)	northern rat flea	rat flea
Paratetranychus ilicis (McG.)	holly spider mite	southern red mite
Scutigerella imaculata (Newp.)	garden symphylid	garden centipede

G. J. HAEUSSLER, *Chairman*

"Catalog of Termites of the World" is the title of a 490 page publication issued November 1, 1949, as Smithsonian Miscel. Coll. Vol. 112, Publ. 3953. This modern classification of termites was prepared by Dr. Thomas E. Snyder of the Division of Forest Insect Investigations, BEPQ, in cooperation with Dr. A. E. Emerson of the University of Chicago. The termites are classified from the most primitive to the most highly specialized types, and new genera and species are included. This publication, which sells for $3.00, contains a species index and bibliography.

BOOK REVIEWS

CONTRIBUTIONS TO THE KNOWLEDGE OF THE DANISH AND FENNOSCANDIAN MOSQUITOES. Culicini. Suppl. I, by Leif R. Natvig. Norsk Entomologisk Tidsskrift, xvi–567 p., 148 figs. & 12 plates. 1948. For sale by A. W. Brøggers Boktryrkkeri A/S, Karl Johans gt. 12, Oslo, Norway. Price: Norw. Kr. 50.00 (U.S. $10.00).

To anyone interested in North American arctic and subarctic mosquitoes, this comprehensive work is most valuable since it includes 19 circumboreal species found in the American hemisphere. The 35 species of Culicine mosquitoes of Norway, Sweden, Denmark, and Finland are fully treated by presentation of keys to the species, synonymy with extensive remarks, descriptions of females, males and terminalia, and larvae. The male terminalia, female palpi, and larval characters are illustrated by original line drawings. The geographical distribution of each species is presented in detail for the Danish-Fennoscandian countries, and extensive Eurasian and some North American records are included. The biology of each species is a compilation of the observations of Wesenburg-Lund and others, with some original additions.

Of special interest are quotations concerning the very severe pest mosquito problem in the far North. Natvig disagrees with Thienemann that small rodents are the main blood source of the abundant northern mosquitoes and "considers the reindeer the chief source of blood for the arctic mosquitoes." In the opinion of the reviewer, evidence indicates that nearly all warm blooded animals of the arctic serve as hosts to mosquitoes. A limited amount of evidence indicates that flowers supply nourishment to some northern mosquitoes.

The origins and distributions of the Fennoscandian mosquitoes are discussed in relation to Hultén's theory. *Aëdes pullatus* and probably *A. nigripes* and *A. nearcticus* are considered to be survivors of the Würm glaciation in Norway, and the rest of the Fennoscandian mosquitoes are considered to be postglacial immigrants.

One of the most important contributions of this volume is the translation and compilation of the extensive Norwegian, Swedish, Danish, Finnish, and Russian literature into English. Quotations from German are in the original language. Twenty-seven pages of references are presented which illustrate the scope of the subject.

Supplement II will be on the Anophelini of the same region. Dr. Natvig's monumental contribution to northern mosquito studies includes 18 seasons of field investigations, and examination of all available mosquito material in the museum collections of Norway, Sweden, Finland, and Denmark. The author is to be congratulated for continuing his studies through the war period. This work will undoubtedly be the standard reference on mosquitoes of this area for many years.

DALE W. JENKINS

PRINCIPLES OF INSECT PATHOLOGY, by Edward A. Steinhaus. 1949. xi+757 pp. $8.00. McGraw-Hill Book Company, New York.

Every entomologist who is concerned with either killing insects, or propagating insects, or with learning how they tick, may read *Principles of Insect Pathology* with profit. Pathology "in a broad sense refers to observations concerning the cause, symptomatology, and epizoötiology of the diseases of insects, and to a study of the structural, chemical and functional alterations in the body of the insect resulting from disease or injury." Following the introduction is a short chapter on mechanical, physical and chemical injuries, and the injuries due to parasitization by insects or arachnids; another chapter on diseases of nutrition and metabolism. Then come two chapters on the types of micro-flora and fauna found in normal insects, in order that the student may differentiate such inhabitants from the abnormal. The normal biota include bacteria, fungi, rickettsiae, protozoa, and viruses living both extracellularly and intracellularly. Considerable space is given to the symbiotes inhabiting the peculiar bodies in insects called mycetomes. Three short chapters cover infection and epizoötiology, resistance and immunity, and symptoms and pathologies. These considerations naturally follow much of the theory and nomenclature used in human and animal pathology. Symptoms of insect disease have not been well studied or cataloged and the histopathology of insect tissues is one of the subjects most in need of study. The longest chapter in the book deals with virus infections; those chapters on bacterial, fungous, and protozoan infections are nearly as long. There is a systematic arrangement of the viruses connected with insect disease in the family *Borrelinaceae* Holmes, in four genera, differentiated on the nature of the polyhedral bodies and other inclusions. Of the four genera two are newly described.

No small part of our knowledge of insect disease has arisen from the studies of the troubles of our two domesticated insects—the silkworm and honeybee. Especially interesting is the account of Pasteur's solution of pebrine, a protozoan disease of the silkworm which seriously affected the silk industry in Europe a century ago. "It was this experience and self-training which later was to give him background and incentive to delve into the mysteries of animal and human disease.—Medical science owes a debt not only to Pasteur, but to the silkworm and its disease!"

Writers from the time of Aristotle noted the diseases of bees, but not until the 20th century did G. F. White isolate and describe the bacterium causing American foulbrood. One of the first fungus-borne diseases to be studied is the *Empusa* on the housefly described by Cohn in 1855. Within another ten years diseases of grasshoppers and the chinch bug had come up for study. The numerous brief accounts of human endeavor in the realm of insect pathology add greatly to the book's interest.

The final chapter deals with applied insect pathology and biological control. Most of the trials of controlling insect pests by microbes have met with inconsistent results. The author believes this was usually due to the incomplete studies of the factors involved. Thus in the failures of grasshopper control by *Coccobacillus acridiorum*, following d'Herelle's preliminary success in Mexico, three facts stand out. Differences in susceptibility according to species of grasshopper; differences in species and strain of the bacterium disseminated; and thirdly, there was an immunizing effect on grasshoppers from using the bacterial strains of low virulence. The author holds a "hopeful conservatism" in regard to the use of microbes to control insects, believing this method

should complement control by insects and chemicals. He stresses the need for basic research in items mentioned above and in the effects of climate and daily weather on disease organisms. But the concluding thought is "The student who goes into the field of insect pathology for the sole purpose of making practical use of it will not find the contentment found by him who goes into the field because he is compelled to do so by virtue of his deep interest or insatiable curiosity in this area of Nature's activity."

THEO. L. BISSELL

Joint meetings of the American Mosquito Control Association and the Virginia Mosquito Control Association will be held on February 23 and 24 at the Cavalier Hotel, Virginia Beach, Virginia. High points of these meetings include a discussion on DDT resistant mosquitoes, and new insecticides for use in 1950, led by Dr. F. C. Bishopp of the U. S. Bureau of Entomology and Plant Quarantine and the use of radioactive isotopes, led by Dale Jenkins of the Army Chemical Center, Maryland. In addition a motorcade will start on February 25, from Virginia Beach, proceed to Williamsburg, Va., Maryland, Delaware, and terminate in Atlantic City on March 1, where the New Jersey Mosquito Control Association meetings will take place from March 1 through March 3. The motorcade will inspect mosquito control work and visit points of historical interest en route.

Further details can be obtained from R. E. Dorer, Room 204, Essex Building, Norfolk, Virginia.

U. S. BEPQ CHANGES AND APPOINTMENTS

William Robinson, who had been performing specialized work on micro techniques at Orlando, Florida (Division of Insects Affecting Man and Animals) asked for voluntary retirement at the end of August. He has accepted a position with the Orlando Junior College, Orlando, Florida, as a Professor of Biology.

Bernard V. Travis, assistant station leader at the Orlando, Florida laboratory of the Division of Insects Affecting Man and Animals, resigned September 30, 1949, to join the faculty of Cornell University.

James M. Coarsey, who had been employed by the Division of Insects Affecting Man and Animals at the Savannah, Georgia laboratory, and engaged for the past several years on survey work, has been promoted and placed in charge of the Imported Fire Ant Research project at Spring Hill, Alabama, effective September 8.

John Carolos Keller, formerly employed as an entomologist with Soil Plant Services at Arvada, Colorado, was appointed September 30 as a member of this Bureau. He is stationed at the Orlando, Florida laboratory of the Division of Insects Affecting Man and Animals working on the Premises Treatment Project.

Leyburn F. Lewis, formerly employed by the Grasshopper Control Division of the Bureau, transferred to the Division of Insects Affecting Man and Animals, and has been assigned to the Savannah, Georgia laboratory working on research connected with livestock parasites under Southeast conditions.

Hugh I. Alford, Jr., previously a student at the University of Wyoming accepted an appointment offered by the Division of Insects Affecting Man and Animals of the Bureau, and has been assigned to the Kerrville, Texas laboratory where he will work on the problem of treatment of wounds of animals with different insecticides in order to prevent infestations of screwworm flies.

A recent graduate of the Colorado A. & M. College, Orville Carl Schomberg, has been assigned for a temporary period to the laboratory at Stillwater, Oklahoma of the Division of Insects Affecting Man and Animals to work on research on the biology and control of deer flies. It is anticipated that his permanent headquarters will be Kerrville, Texas.

W. L. Baker of the Division of Forest Insect Investigations transferred, effective in July, from Columbus, Ohio to Beltsville, Maryland where he assumed the duties of Assistant Division Leader. Mr. Baker formerly was engaged in a study of insect vectors of elm diseases, particularly insects associated with phloem necrosis, a virus of American elms in the mid-West.

Another transfer in the Division of Forest Insect Investigations involved Mr. W. D. Buchanan. Mr. Buchanan was formerly stationed at Ft. Collins, Colorado and in September went to Columbus, Ohio where he has undertaken a study of insect vectors of elm diseases. Mr. Buchanan's former work involved a study of natural enemies of the spruce budworm in the Rocky Mountain area with emphasis on collection of parasites for shipment to eastern areas where the budworm is active.

A new appointee to the Division of Forest Insect Investigations is J. W. Butcher who has been assigned to the Milwaukee, Wisconsin laboratory, effective July 1949. Mr. Butcher is a graduate of the University of Pittsburgh with graduate studies at Minnesota and will study problems concerned with insects affecting forest plantations and second growth stands in the Lake States area.

Effective in March 1949, A. T. Drooz was appointed to the Beltsville, Maryland Laboratory of the Division of Forest Insect Investigations. Mr. Drooz was an undergraduate and graduate student of Syracuse University formerly. His assignment at Beltsville will deal with the effects of DDT aerial sprays on beneficial insects and wild life.

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